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FOURIER ANALYSIS FORECASTS OF HOVMÖLLER  
DIAGRAM HEIGHTS

by



Phillip G. de Souza

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE  
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IN

METEOROLOGY

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Fourier Analysis Forecast of Hovmöller Diagram Heights", submitted by Phillip de Souza in partial fulfilment of the requirements for the degree of Master of Science, in Meteorology.





This is dedicated to my daughter,  
Adrienne.

I got this finished, inspite of her.





## ABSTRACT

A computer program was developed to analyze Hovmöller Diagram data.

The program uses Fourier Analysis to extract wave information from the individual reports. Fourier Analysis is used again to get information as to how these waves change with time. A 30-day forecast of the data is then made for the period covered by the next 60 reports.

The program was used on two sets of data obtained from the Atmospheric Environment Service, Department of Forestry and the Environment.

The results indicate a possible relation between the means of the reports and the solar radiation. Some forecast skill was shown when comparisons were made to climatology and persistence forecasts. However, the error in the best forecasts was rather large for operational applications at a Weather Office.



## PREFACE

In 1949, E. Hovmöller (1949) introduced the Trough-and-Ridge Diagram. Such diagrams show how the 500-mb heights change with longitude and time. Oscillations or waves in these heights produce ridges and troughs which can be tracked for several days, weeks, and in the case of long waves, even months. Forecasters at the Atmospheric Environment Service (AES) have used this diagram as an aid to forecasting the movement of troughs, ridges, and energy pulses. In current practice, the forecast method is partly subjective and only indicates the possible locations at which rapid deepening of surface cyclones may occur.

A second method using Fourier Analysis has also been developed at AES, a numerical forecast scheme which predicts the 500-mb heights and, in this way, indicates the location and magnitude of possible deepening. At the time of writing, little is known about the accuracy of this method (see Balshaw(1975)).

This report examines two Fourier Analysis models for forecasting the 500-mb heights displayed in a Hovmöller Diagram.

The first model assumes that the mean of the





heights and the amplitude of the waves are constant. The second model assumes that the mean and wave amplitudes vary with time. Forecasts of up to thirty days were produced using the second model and statistics are calculated to show the "skill" of the forecast method.



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## CHAPTER 1

### INTRODUCTION

#### Analysis of Data

Every twelve hours, at 00 GMT and 12 GMT, two sets of seventy-two Hovmöller Diagram heights are produced at the Canadian Meteorological Centre (CMC). One set of heights refers to a latitude belt from  $50^{\circ}\text{N}$  to  $75^{\circ}\text{N}$ , the Northern Data set. The other set of heights refers to a latitude belt from  $30^{\circ}\text{N}$  to  $65^{\circ}\text{N}$ , the Southern Data set.

#### 1.1 Height Set Production

Each of the seventy-two numbers of the height set is obtained by taking a six-point average, along a selected line of longitude, of the 500-mb heights within the latitude belt. The lines of longitude selected are five longitude degrees apart. The first number in the height set refers to  $30^{\circ}\text{W}$  longitude. Each succeeding number refers to the longitude line five longitude degrees to the east of the previous line. In this way, a report represents a set of heights averaged over a complete zonal band around the Earth. Figure 1.1 shows the posi-





Figure 1.1. Estimated Mean Surface Elevation Above Sea Level  
In the Latitude Belt of Each Data Set





tion of the numbers and an estimate of the altitude of the surface at those longitudes for both Northern and Southern Data sets. The heights, reported by CMC, are in decameters (dam) with the hundreds digit deleted. This means that if one of the numbers is 56, then the actual average height for that line of longitude is 556 decameters. However, for the Northern Data set, this lack of a hundreds digit could produce possible ambiguities since a height coded as 99 could mean a height of 499 decameters or 599 decameters. These 499 dam or lower heights usually occur in the Northern Data set during winter. This possible problem was removed by subtracting 500 decameters from the actual heights. This changed some values to negative numbers. The height-sets were then punched on computer data cards and separated into the two groups, Northern and Southern Data sets.

There are two different ways to analyze the height data, either by graphical or by numerical techniques.

## 1.2 Graphical Techniques

Hovmöller(1949) was the first person to propose a method to analyze his Trough-Ridge diagram. His method as described in Balshaw et al.(1975) is still being used today. This technique consists of plotting the set of heights using longitude as abscissa and time as ordinate.



Then equi-height contours are drawn on the plot. Intervals of 10 decameters were used by Hovmöller, but other researchers have used different contour intervals. For example, Bjerknes(1957) used an interval of 4 decameters and AES forecasters use 6 decameters. Once contours have been drawn, areas of minimum heights (LOWS) and areas of maximum heights (HIGHS) are shaded in. At a specific time, the position of a height minimum or height maximum is called a trough or ridge, respectively. Lines connecting the various time positions of a trough or ridge are drawn to show the movement of these features.

Two types of waves can usually be diagnosed in these diagrams, long waves (wave no. 1 to 3) and major waves (wave no. 4 to 7). Long waves are usually slow moving or even stationary in the Hovmöller Diagrams. Major or secondary waves usually have trough or ridge lines sloping at varying angles to the abscissa. To forecast the height pattern, these trough and ridge lines are extrapolated past the most recent data. Constructive wave interference is expected at the location and time at which two trough lines or two ridge lines intersect. If two ridge lines intersect, then a HIGH is expected and, if two trough lines intersect, a LOW is expected. Reaction at the surface to these lows and highs can be expected about five longitude degrees to the east of these features.



### 1.3 Numerical Techniques

As mentioned previously, the height data at any given time are repetitive in space for every complete circuit around the Earth. Most numerical techniques take advantage of this fact and analyze the data using a Fourier Analysis. This produces values for the amplitude and phase of the dominant waves in the data. A dynamic equation such as Rossby's wave equation can then be used to forecast wave motion.\* The Rossby wave equation is used by Balshaw et al.(1975).

### 1.4 Initial Model

The initial attempt at forecasting the heights for the Hovmöller Diagram also used a Fourier Analysis to extract space-wave information from the height sets. The formulas used were those of Jenkins and Watts (1968):

$$S(L) = A_0 + 2 \sum_{m=1}^k \{ A(m) \cos(D(L,m)) + B(m) \sin D(L,m) \} \\ + A(k+1) \cos(D(L,k+1))$$

where  $D(L,m) = \frac{2\pi}{N}(L-L_0)m$

---

\* Page 255 Hess(1959) or page 144 Petterssen(1956). Another dynamic equation is the Cressman's equation (page 160 Petterssen(1956)).





L0 = spatial origin of wave reference  
system = 37

L = spatial location of the height value  
in the CMC report set;  
L = 1 for the first number in the set, and  
L = 72 for the last number in the set.

N = 72 = the total number of values in  
the set

A0 = the mean height of the set

2B(m) = sine component of the amplitude  
of the space-wave having wave  
number m

m = wave number = number of space-waves  
required to completely circle the Earth

$k = \frac{N}{2} - 1$  = maximum number of waves  
having a non-zero sine component

A(k+1) = amplitude of wave with wave number  
k + 1.

The amplitudes for these waves in space were calculated  
by:

$$A(m) = \frac{1}{N} \sum_{L=1}^N S(L) \cos(D(L,m))$$

$$B(m) = \frac{1}{N} \sum_{L=1}^N S(L) \sin(D(L,m)).$$

This form of the amplitude equations was converted to the amplitude - phase form by the equations:

$$S(L) = A0 + \sum_{m=1}^k 2R(m) \cos(D(L,m) + Q(m)) \\ + R(k+1) \cos(D(L,m))$$

where  $2R(m) = 2\sqrt{A(m)^2 + B(m)^2}$  = amplitude



$$Q(m) = \arctangent(-B(m)/A(m)) = \text{phase}.$$

This conversion requires that:

$$A(m) = R(m)\cos(Q(m))$$

$$B(m) = -R(m)\sin(Q(m)).$$

The Rossby wave equation was not used to forecast movement of the waves. Instead, a simple rate of phase-change equation was developed.

$$V(m) = \frac{\Delta Q(m)}{\Delta t} = \frac{1}{\Delta t} \arctan \left( \frac{B(0)A(t) - A(0)B(t)}{B(0)B(t) + A(0)A(t)} \right)$$

The derivation of this equation (see Appendix A) requires three assumptions. These assumptions are:

- 1) The mean of the data set at time zero is assumed equal to the mean of any other time,
  - 2) the amplitude of the space-waves,  $2R(m)$ , at time zero is assumed constant for all other times,
- and 3) the phase speed  $V(m)$  is constant with time.

The rest of this chapter is a critical examination of these assumptions.

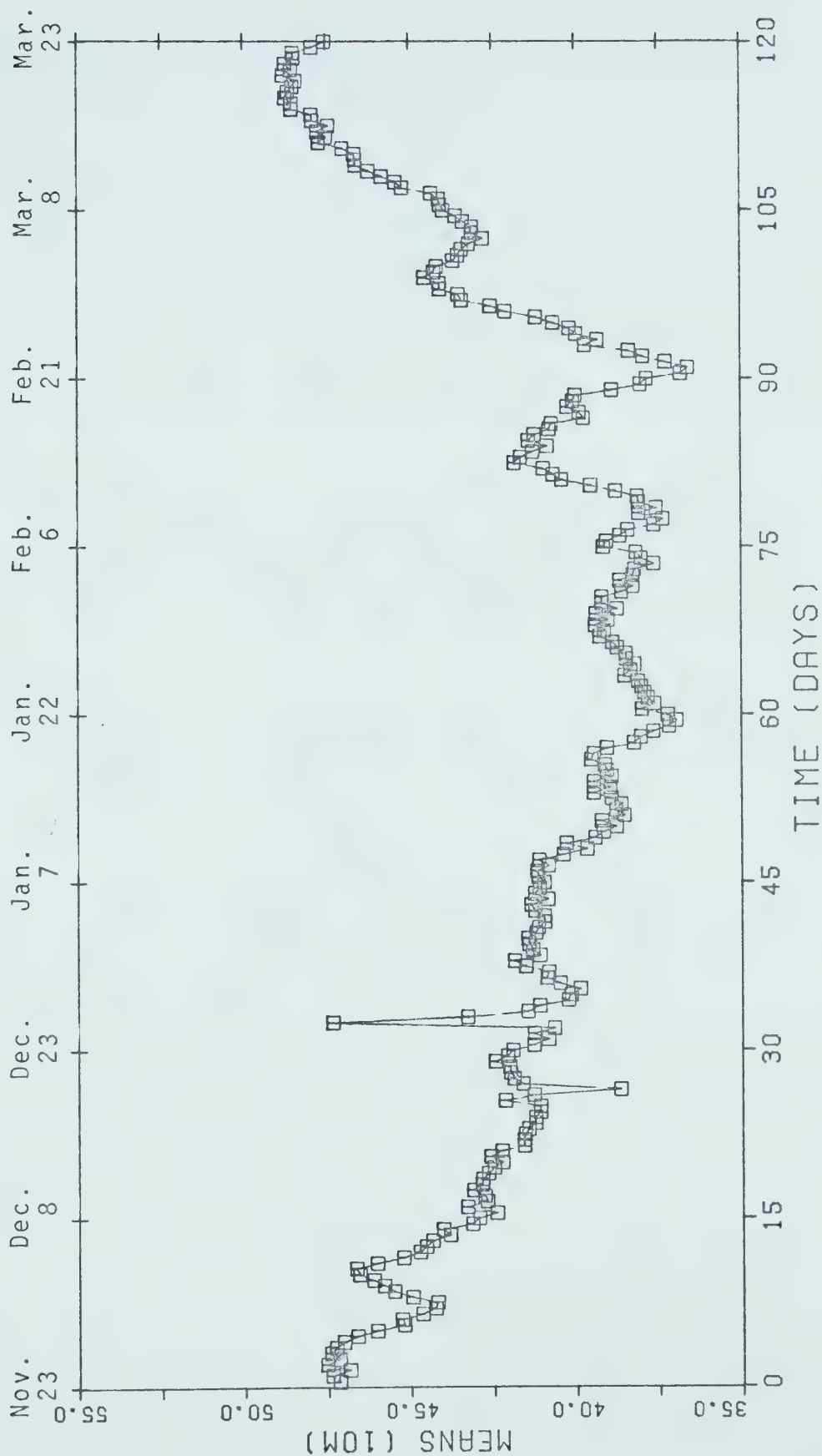
### 1.5 Assumption I: Height-Set Means

Figure 1.2 is a graph of the mean of height-set for Southern Data Set versus time. It can be seen in



Figure 1.2. Calculated Mean of the Height-Set for Time Shown  
(Date or number of days from Nov. 22, 1976)

Southern Data Set





this figure, that the mean,  $A_0$ , of the height-set is not constant with time. The error produced by a forecast made using Assumption I was as much as five decameters after fifteen days. This model would be required to forecast for as long as fifteen days to one month, with an accuracy of  $\pm 5$ -10 dam. Therefore, an error of five decameters for just the mean of the height-set was considered too large.

Examination of Figure 1.2 reveals two types of time fluctuations in the means. The first type was a long-term trend and the other fluctuation type was small amplitude "time-waves".

The trend was assumed to have a yearly period, and to be a function of time of the form

$$A_0(t) = D + H \cos\left(\frac{2\pi t}{730}\right) + C \sin\left(\frac{2\pi t}{730}\right)$$

where  $t$  has units of half-days. The coefficients  $D$ ,  $H$ , and  $C$  were assumed to be constant with time. These coefficients were then determined using a least-square error fit of the means of the height-sets. The derivation of the least-square error formula is shown in Appendix B.

As expected, the calculated trend does fit the diagnostic means well. However, forecasts of the trend beyond the limits of the diagnostic means had a tendency to drift away from the actual means as the forecast time





increased. The error produced was in the range of five decameters for a ten-day forecast. This error was reduced as the number of diagnostic means increased.

Figure 1.3 shows the differences  $Y(t)$  between the actual means used as diagnostic data  $S(t)$  and the calculated trend  $A0(t)$ , so that

$$Y(t) = S(t) - A0(t)$$

If these differences were small, then they could have been neglected. However, some of these time deviations were as large as four decameters, and errors of this magnitude in the mean could not be ignored.

All in all, Assumption I was shown to be poor for the desired forecast period.

## 1.6 Assumption II: Wave Amplitudes

The second assumption is that the amplitude of each space-wave is constant with time. Figure 1.4 shows how the amplitude,  $2R(m)$ , of wave number  $m = 1$ , changes with time in the Southern Data Set. Other graphs of amplitude versus time can be found in Appendix C and D.

As expected from work with Hovmöller Diagrams, the largest amplitudes (10 to 15 dam) occur for space-waves that have wave numbers one to four. However, the



Figure 1.3. Differences Between Means of Reports and Calculated Trend  
for the Time Shown. (Date or number of Days from Nov. 23. 1976)

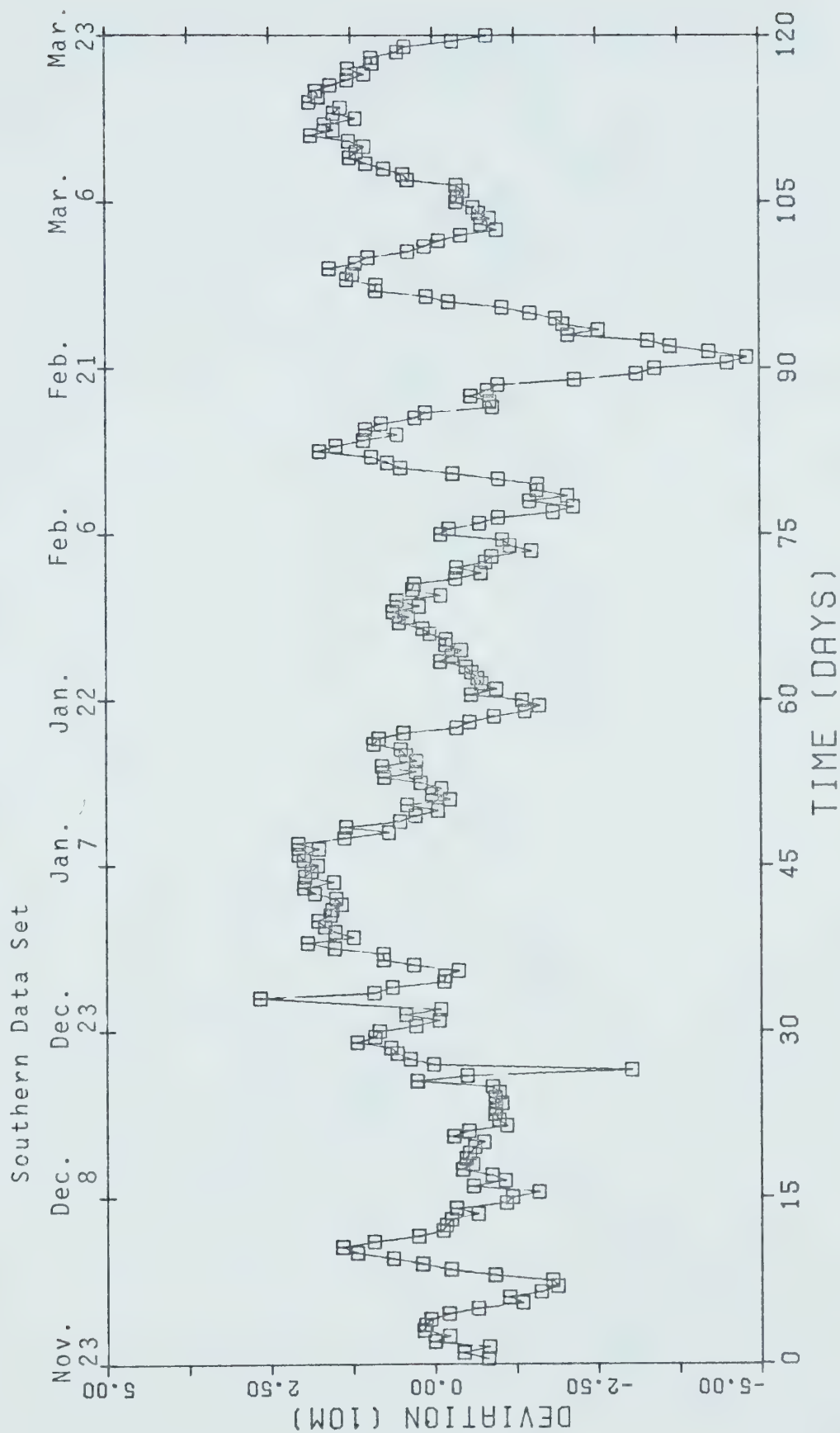
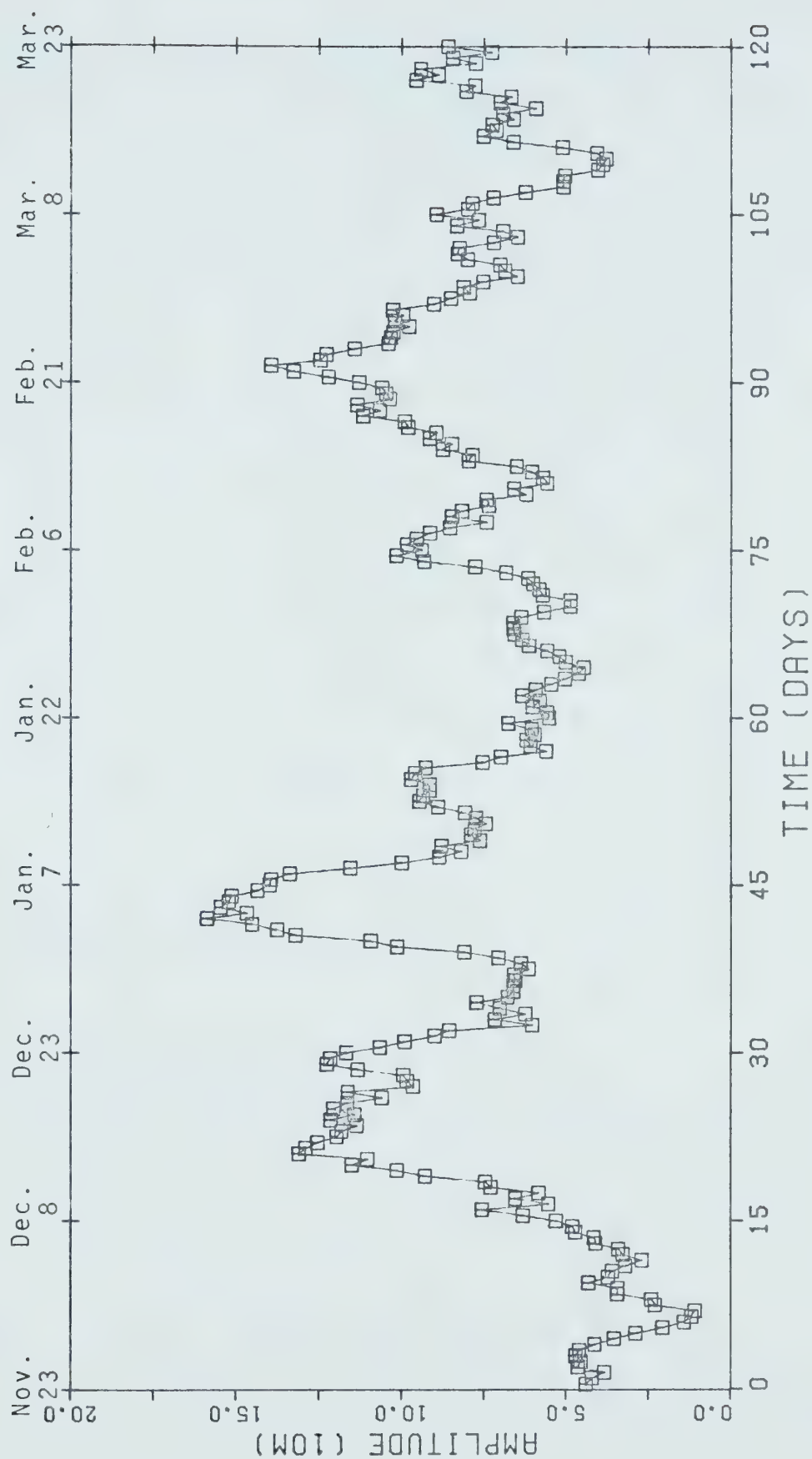




Figure 1.4. Amplitude of Space-Wave with Wave Number 1, for Time Shown

Southern Data Set





time fluctuations of amplitude for these space-waves were larger and more frequent than expected. For example, the amplitude of wave number 1 changed from 5 dam to 15 dam over a period of four days.

For space-waves with wave numbers five to twenty-five, the amplitudes decrease as wave numbers increase. After wave number 11, the maximum amplitude observed was less than 2 dam. For this reason, space-waves of wave numbers greater than eleven were ignored.

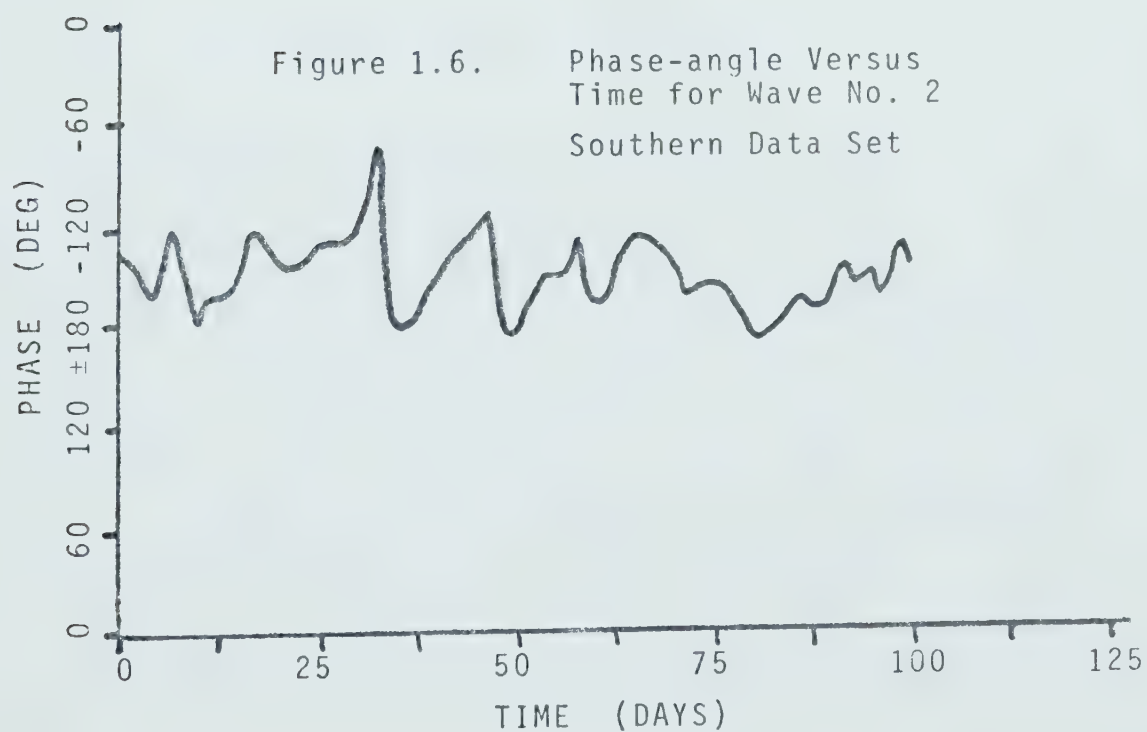
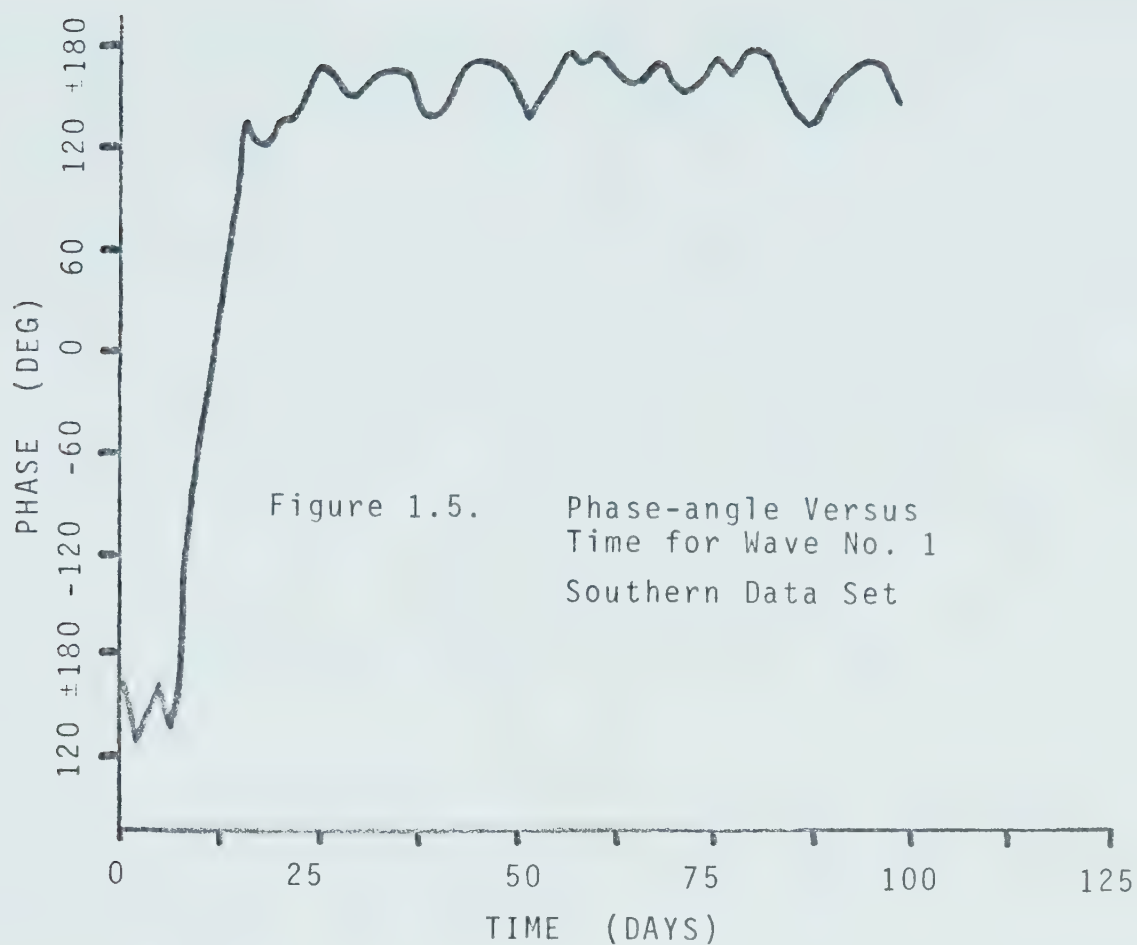
The time fluctuations observed in these space-wave amplitudes could have been produced by the Fourier Analysis calculation and might not have indicated a true time fluctuation in the waves in the atmosphere. These fluctuations were fairly smooth and continuous over two to four days of data, which indicates that a true dynamic process produced them. However, these time fluctuations were not consistent with Assumption II.

### 1.7 Assumption III: Wave Phase

The last assumption, that the change of phase-angle is constant with time, was also checked. The calculated phase-angle for each space-wave was plotted against time (see Appendix E). Figure 1.5 and 1.6 show corrected phase versus time plots for wave numbers 1 and 2. It can be seen in Figure 1.5 that









for most of the diagnostic period, wave number 1 is quasi-stationary, with a phase-angle of  $+150^{\circ}$  (origin at  $150^{\circ}\text{E}$  longitude). For eight days, however, a rapid retrogression was detected with a speed of 150 km/hr or about 81 kts. (See Appendix F for method of calculating wave speed). This unexpected time fluctuation of phase-angle would be handled poorly by the initial model. Other graphs for the phase-angle versus time also show rapid fluctuations of phase-angle with time, which would indicate wave speeds of 15 to 20 kts., or about 25 to 35 km/hr.

The question again presents itself. Does the calculated fluctuation represent a true wave motion in the atmosphere? The phase-angle calculation

$$Q(m) = \arctan(-B(m)/A(m))$$

is sensitive when the ratio  $-B(m)/A(m)$  is close to zero but insensitive when the magnitude of the ratio  $-B(m)/A(m)$  is greater than four. This problem would not explain the slow  $360^{\circ}$  shift shown in Figure 1.5 but it might explain time fluctuations in the other space-waves.

Other problems associated with the amplitude-phase representation of the space-waves were:

- 1) The computer arctangent calculation only allows for phase-angles between  $\pm 180$  degrees.



When the phase-angle has a magnitude near 180 degrees, then a slight time fluctuation might cause a phase-angle sign change. This problem can be solved with proper computer programming but this was not attempted in this study.

and 2) Long-time averages over a 10 to 20 day period are required to produce smooth phase changes. This also was not attempted in this study.

These graphs show that not only is the phase hard to work with but also the assumption of constant phase velocity is not correct.

These studies of the three assumptions required to use the initial model showed the assumptions to be poor when actual data are used. Also, the various problems associated with the phase-angle calculation and interpretation suggest that adjustments to the model are needed for useful forecasts.

### 1.8 Final Numerical Model

The initial model had to be changed to a new form that would reproduce the Hovmöller Diagram heights with greater accuracy. The quantities  $A_0$ ,  $A(m)$  and  $B(m)$ , that were assumed constant with time in the old model, were assumed to be periodic functions of time in the new model. The form of this time dependence was, for  $A(m)$  and  $B(m)$



$$A(m) \rightarrow A(t,m) = RA(m) + 2 \sum_{I=1}^{NWAVE} \{FA(I,m) \cos(E(t,I) + QA(I,m))\}$$

$$B(m) \rightarrow B(t,m) = RB(m) + 2 \sum_{I=1}^{NWAVE} \{FB(I,m) \cos(E(t,I) + QB(I,m))\}$$

where NWAVE = maximum number of waves used to forecast amplitudes

m = wave number,  $1 \leq m \leq 11$

RA(m) = mean of cosine amplitude  $\div 2$  for space-wave with wave number m

RB(m) = mean of sine amplitude  $\div 2$  for space-wave with wave number m

2FA(I,m) = amplitude component of time-wave having wave number I. (cosine)

2FB(I,m) = amplitude component of time-wave having wave number I. (sine)

QA(I,m) = phase angle of forecast time-wave having wave number I. (cosine)

QB(I,m) = phase angle of forecast time-wave having wave number I. (sine)

$$E(t,I) = \frac{2\pi \cdot I \cdot}{NUMB} (t - (\frac{NUMB}{2} + 1))$$

And, for the means of the height sets

$$A0 \rightarrow A0(t) = R0 + G \cos(\frac{2\pi t}{730}) + H \sin(\frac{2\pi t}{730})$$

$$+ 2 \sum_{I=1}^{NWAVE} \{K(I,m) \cos(E(t,I) + Q0(I,m))\}$$

where R0 = time mean of all height-set means





$G, H$  = amplitudes of trend component

$2K(I, m)$  = amplitude of forecast time-wave  
of differences  $Y(t)$  mentioned in  
section 1.5

$Q0(I, m)$  = phase of forecast time-wave of  
differences  $Y(t)$ .

Note that the space-wave amplitudes do not have a trend removal or a trend forecast.



## CHAPTER 2

### PROGRAM TO FORECAST HEIGHTS

Figure 2.1 shows a block diagram of the two computer programs used to forecast Hovmöller Diagram Heights.

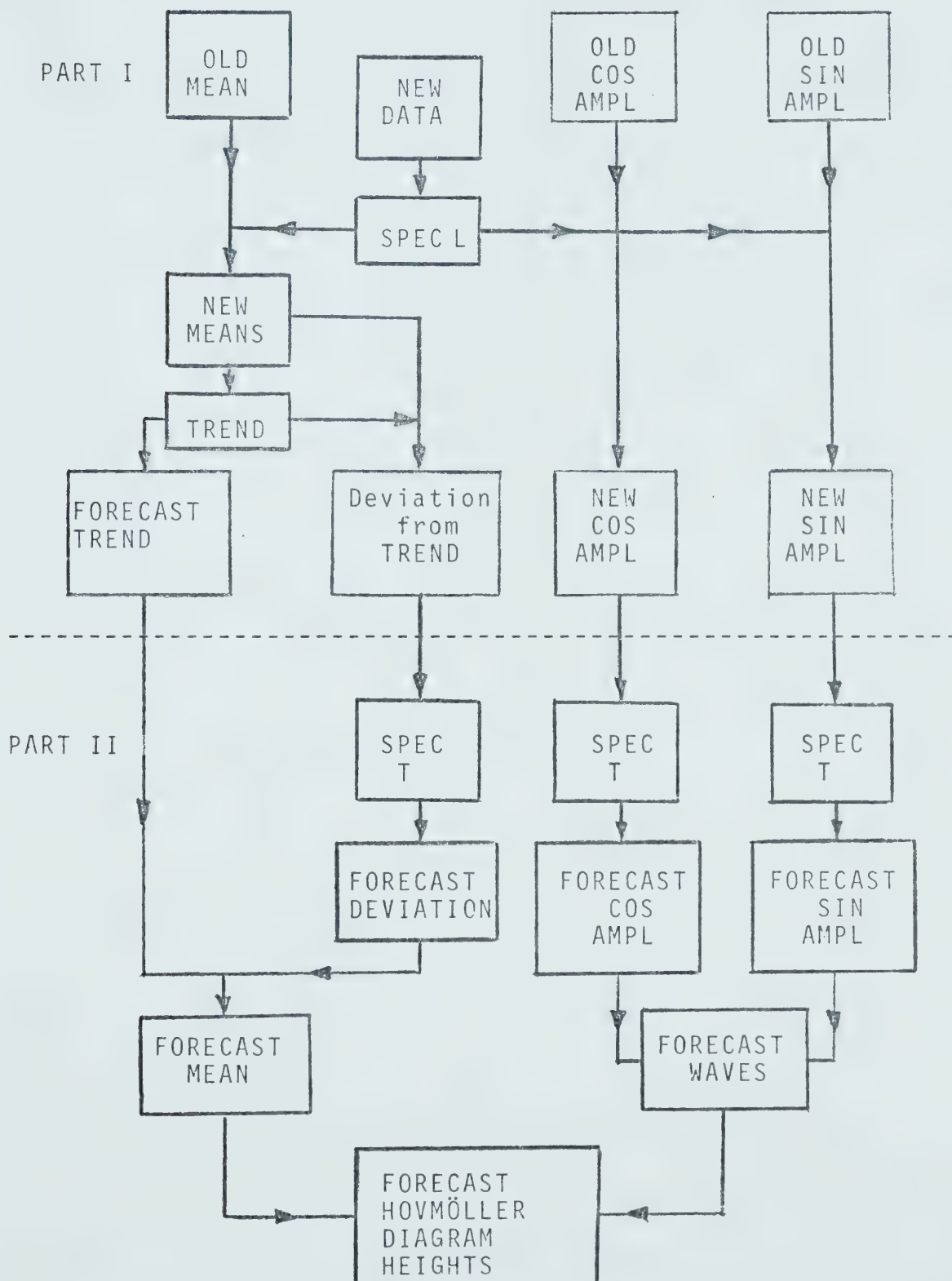
#### 2.1 Program I: Data Collection

The first program collects data and updates diagnostic fields. As a new set of heights for time " $T^*$ " is read into the computer, a space Fourier Analysis is performed on it. The mean height,  $A0(t^*)$ , of each report becomes the last element in a vector,  $Y(t)$ , that contains previous means of diagnostic data for time  $t=1$  to  $t = t^*-1$ . The 22 components of the space amplitude:2 i.e.,  $A(t,m)$  and  $B(t,m)$ , become the eleven elements in the last row of two storage matrices,  $AAMPL(t,m)$  and  $BAMPL(t,m)$ , respectively. The first element in the rows of these matrices represents the component for wave number  $m=1$ , and the last element in the rows represents the component for wave number  $m=11$ .

Next, a least-square time analysis is performed on the means stored in vector  $Y(t^*)$ . This produces the



Figure 2.1. Block Diagram of the Two Parts of the Program





trend equation in the form previously given in section 1.8. The trend is calculated for the diagnostic data  $Y(t^*)$  and is extended outside the diagnostic period for a thirty-day forecast period. The difference, between the real means in vector  $Y(t^*)$  and the estimated trend  $X(t^*)$  is computed and stored in vector  $Z(t^*)$ .

If a 12-hr report was missing for time  $t'$ , then three blank cards were read into the computer in its place. The program will then set the space amplitude components  $A(t',m)$  and  $B(t',m)$  equal to 99.99 for the eleven wave numbers, and the mean  $Y(t')$  is set equal to zero. For the calculation of the deviation from the trend,  $Z(t')$ , the missing data are replaced by a local time average. This time average is taken over the six (or fewer) non-zero values of  $Y(t)$ , three on each "side" of  $Y(t') = 0.00$ . The complete listing and output of the first part of the height forecast program is shown in Appendix G.

## 2.2 Program II: Height Forecast

The second part of the program \*\* takes a time Fourier Analysis of the amplitudes in each column of the two matrices AAMPL and BAMPL, and it takes a time Fourier Analysis of the deviations in  $Z(t^*)$ . On each occasion that a time Fourier Analysis is carried out, the

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\*\* See Appendix H for a listing of Program II





resultant time-waves are sorted according to the magnitude of the time-wave amplitudes. Large-amplitude time-waves are listed first and small-amplitude time-waves are listed last.

At this point, the program can perform in various optional ways. To determine which of these options is used, five parameters must be specified (see Appendix I for a complete description of these parameters). The three most important of these parameters are NWAVE, PRINT and JWAVE. The first NWAVE of the sorted resultant waves are used to forecast the amplitudes in the columns of AAMPL and BAMPL, and to forecast the deviations  $Z(t)$ .

The second parameter, PRINT, is the most important. It allows forecasts to be made using persistence, climatology, unsmoothed time-waves, and smoothed time-waves. A persistence forecast ( $PRINT = 4.0$ ) just repeats the most recent diagnostic report over the full forecast period\*. A climatology forecast ( $PRINT = \pm 5.5$ ) is equivalent to  $NWAVE = 0$ . This means that only the average of each column is used to make a time "forecast" of the amplitude in each column of AAMPL and BAMPL. It also means that the average of  $Z(t)$  is used to "forecast" the deviations from the trend. For unsmoothed time-waves to be used, PRINT must have a value greater than 6.0. If

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\* For a persistence forecast, only the Verification Program needs to be run (see Appendix J).



PRINT is less than 3.5, time-smoothed waves are used to forecast the columns of AAMPL and BAMPL, and the deviations in  $Z(t)$ . This smoothing is performed on the time-waves before they are sorted according to magnitude.

The third important parameter, JWAVE, determines the number of space-waves (number of columns of AAMPL and BAMPL) to be used to forecast the heights. This parameter also can have a value from 1 to 11.

Once the number of space-waves, JWAVE, has been specified, the strongest NWAWE time-waves forecast the first JWAVE columns of AAMPL and BAMPL and the deviations from the trend  $Z(t)$ . The heights for a forecast time  $(t+1)$  are then reconstituted from the forecast trend, the deviation from the trend  $Z(t+1)$  and the forecast space-wave amplitudes in AAMPL  $(t+1,m)$  and BAMPL  $(t+1,m)$ .



## CHAPTER 3

### SMOOTHING

The time variation of the frequency of the time-waves is one of the major problems with this forecast model. Therefore, instead of the wave being represented by a single frequency, as in the model, it should be represented over a frequency band, with the band width depending on the wave. This causes an error in the forecast of the space-wave amplitudes in the columns of the matrices AAMPL and BAMPL. The forecast program assumes that the time-waves, diagnosed in the columns of AAMPL and BAMPL, have a fixed wavelength during the whole forecast period.

To try and minimize the problem of wavelength variations during the forecast period, a time smoothing was performed in Program II. Three different smoothing options were tested.

#### 3.1 Smoother Number 2

Lachapelle(1977) suggested one method of smoothing the waves. In this method the mean-square contribution for wave I, AA(I), is calculated by the formula:



$$\{\text{amplitude}/2 \cdot \text{amplitude}/2\} \cdot 2.$$

The average of  $AA(I)$  over three waves is taken to be the smoothed mean-square. The frequency "f" is weighted using the mean-square as weights. Also the phase "Q" is smoothed by taking the average of the sine "BR" and cosine "AR" components. The arctangent of the ratio  $BR/AR$  is then taken to represent the smooth phase.

This method was used as one smoothing option. The only change was due to a different definition for the phase. Lachapelle(1977) used the form  $R\cos(X-Q)$  in his time spectral analysis. In this program the form  $R\cos(X+Q)$  was used. This required the arctangent of the ratio  $-BR/AR$  to be used for the smoothed phase.

To switch between amplitude-phase and sine-cosine forms, use the formula:

$$\begin{aligned} B(I) &= -R(I)\sin(Q(I)) & AA(I) &= R(I)*R(I)*2 \\ A(I) &= R(I)\cos(Q(I)). \end{aligned}$$

For wave number I, smooth mean-square =  $\{AA(I-1) + AA(I) + AA(I+1)\}/3$

$$AR = \{A(I-1) + A(I) + A(I+1)\}/3$$

$$BR = \{B(I-1) + B(I) + B(I+1)\}/3$$

$$\text{smooth phase} = \text{arctangent} (-BR/AR)$$

$$\text{smooth frequency} = \frac{f(I-1) \cdot AA(I-1) + f(I) \cdot AA(I) + f(I+1) \cdot AA(I+1)}{AA(I-1) + AA(I) + AA(I+1)}$$





This formulation appeared to produce smooth phase-angles, but forecasts made using these smoothed angles showed phase shift problems when compared to the diagnostic data. Two other smoothing techniques are available in the program. Smoother No. 1 and Smoother No. 3 are both slight variations of Smoother No. 2, that try to couple the calculation of smooth phase and smooth amplitude.

### 3.2 Smoother Number 1

In this option the frequency and phase were both smoothed as in Smoother No. 2. However, the mean-square was calculated from a formula similar to that used to add three vectors in two dimensions. The resultant vector magnitude represents the smooth amplitude and its direction represents the phase. For wave number I

$$AR = \{A(I-1) + A(I) + A(I+1)\} / 3$$

$$BR = \{B(I-1) + B(I) + B(I+1)\} / 3$$

as before, but the smooth mean-square =  $2(AR^2 + BR^2)$ .

This linked the calculation of the smooth mean-square and the smooth phase by using AR and BR in both.

### 3.3 Smoother Number 3

This option uses the mean square in both the



smooth phase calculation and the smooth mean-square calculation. For the smooth phase calculation, a problem arises since the mean-square is always positive and contains no phase information. To counteract this problem the program uses the form  $2(\text{magnitude } R) \cdot R$ , instead of the mean-square, to preserve the sign.

For wave number 1:

$$AR = \left\{ \frac{A(I-1) \cdot |A(I-1)| + A(I) \cdot |A(I)| + A(I+1) \cdot |A(I+1)|}{3} \right\}$$

$$BR = \left\{ \frac{B(I-1) \cdot |B(I-1)| + B(I) \cdot |B(I)| + B(I+1) \cdot |B(I+1)|}{3} \right\}$$

$$\text{smooth mean-square} = (|AR| + |BR|)^2$$

$$\text{smooth phase} = \arctan (-BR/AR)$$

The following example demonstrates the results of these smoothing options:

### Initial Waves

| I | Frequency f(I)<br>cycles<br>per hour | A(I)<br>cos<br>dam | B(I)<br>sin<br>dam | R(I)<br>AMPL<br>dam | Q(I)<br>PHASE<br>DEG | AA(I)<br>MEAN-SQ<br>DAM SQ |
|---|--------------------------------------|--------------------|--------------------|---------------------|----------------------|----------------------------|
| 1 | 0.00093                              | -0.2534            | -1.1743            | 1.20263             | 102.46               | 2.89266                    |
| 2 | 0.00185                              | -0.9484            | 0.2382             | 0.97782             | -165.90              | 1.91228                    |
| 3 | 0.00278                              | 0.1283             | -0.2334            | 0.26632             | 61.20                | 0.14185                    |



Result of the smoothing options, used for wave number 2 are:

| <u>f(I)</u> | <u>A(I)</u> | <u>B(I)</u> | <u>R(I)</u> | <u>Q(I)</u> | <u>AA(I)</u> |
|-------------|-------------|-------------|-------------|-------------|--------------|
| unsmoothed  |             |             |             |             |              |
| 0.00185     | -0.9484     | 0.2382      | 0.978       | -165.9      | 1.91228      |
| smoother #1 |             |             |             |             |              |
| 0.00134     | -0.35783    | -0.38983    | 0.529       | 132.5       | 0.56002      |
| smoother #2 |             |             |             |             |              |
| 0.00134     | -0.61334    | -0.66945    | 0.908       | 132.5       | 1.64893      |
| smoother #3 |             |             |             |             |              |
| 0.00134     | -0.43896    | -0.63870    | 0.775       | 124.5       | 1.54921      |

### 3.4 Variance Equalization

The total variance is calculated from the sum of the mean-square for each frequency. This variance changes when the mean-squares are smoothed. The program attempts to make the variance after smoothing "SRMAX" equal to the variance before smoothing "SUM". This equalization is performed in the smoothing subroutine by multiplying the power fraction  $AA(I)/SRMAX$  by the variance "SUM." This adjustment technique does not bring the smooth amplitude to the same magnitude as that of the un-smoothed amplitude.

### 3.5 General Comments on the Smoothing Options

The greatest problem that occurred with the



smoothing method was the calculation of a smooth phase. As mentioned previously, Smoother No. 2 and No. 1 both appear to produce phase shifts of  $\pm 20$  degrees for the strongest smooth waves relative to the strongest unsmoothed waves. For a very strong wave, the amplitude would be reduced slightly by smoothing and the phase and frequency should not change. Smoother No. 3 produces little phase-change ( $\pm 3$  degrees) for these strong waves.

In each of the smoothing options the first frequency is smoothed by taking the average between the first and second frequency. The last frequency is never smoothed and is assumed so small that it is not even printed out (only the first 40 frequencies are printed out).





## CHAPTER 4

### VERIFICATION

#### 4.1 Statistics Used

Sixty 12-hour forecasts were made for the 30-day period after the last day of diagnostic data. Several statistics were generated for each of these forecasts.\*

These statistics were:

The mean of the forecast 
$$S0 = \frac{1}{72} \sum_{I=1}^{72} S(I)$$

The mean of the real data 
$$Y0 = \frac{1}{72} \sum_{I=1}^{72} Y(I)$$

The mean difference 
$$= S0 - Y0 = \frac{1}{72} \sum_{I=1}^{72} \{S(I) - Y(I)\}$$

The biased standard deviation of the forecast

$$SS = \sqrt{\frac{1}{N} \sum_{I=1}^{72} (S(I) - S0)^2}$$

The biased standard deviation of the real data

$$SY = \sqrt{\frac{1}{N} \sum_{I=1}^{72} (Y(I) - Y0)^2}$$

The mean absolute difference 
$$= \frac{1}{N} \sum_{I=1}^{72} |Y(I) - S(I)|$$

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\* See Appendix J for verification program listing.



The mean-square error of estimate MSEE =

$$\frac{1}{N} \sum_{I=1}^{72} \{Y(I) - S(I)\}^2$$

The correlation coefficient

$$R = \frac{\sum_{I=1}^{72} \{S(I) - S_0\} \{Y(I) - Y_0\}}{72 \cdot SS \cdot SY}$$

The correlation coefficient without the mean removed

$$COF = \frac{\sum_{I=1}^{72} Y(I) \cdot S(I)}{\sqrt{\sum_{I=1}^{72} Y(I) \cdot Y(I)} \cdot \sqrt{\sum_{I=1}^{72} S(I) \cdot S(I)}}$$

Here, the real data referred to were the actual CMC reported heights. These data were not used in the diagnostic data sets. Therefore, the statistics generated do not depend on the diagnostic data but show how the forecasts would verify in an operational forecast office.

The values of the statistics "R" and "MSEE", the correlation coefficient and the mean-square error of estimate, respectively, seemed to correspond well with subjectively determined good and bad forecasts. Since the forecast model was designed to produce "good" long range forecasts, the average R and the average MSEE of the first 28 forecasts were used as indications of "goodness" of the total forecasts.



## 4.2 Test Sample

To see if the whole program could forecast heights accurately, a test data set was produced. This test sample set contained 11 space-waves and each of these space-waves contained three time-waves.\* A yearly trend was also added to the mean of each test report. The test sample repeated itself after 30 reports, except for the yearly trend.

Near perfect forecasts were made when the program was used with diagnostic data sets of length 30 reports and the time-waves unsmoothed. The length of the diagnostic sets, NUMB, was increased to 44 and 52 reports and forecasts made. The results of these forecasts are discussed below.

## 4.3 Results Using a Test Sample

Figure 5.2 shows how the mean R and mean MSEE statistics were related for the forecasts for various sizes "NUMB" of the test diagnostic data sets. The relation of these means was a linear one with

$$R = 1.00 - \frac{MSEE}{92}.$$

Since these two statistics were related, only one need

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\* See Appendix K for a listing of this program.



be discussed. For NUMB = 30, the maximum MSEE was  $4.2 \text{ (dam)}^2$  over a nine-day period. This excellent result indicates that the program works for data which exactly fit the model.

One of the problems of using a Fourier Analysis model is called wave truncation. This means that the wave being analyzed does not complete an integer number of cycles in the diagnostic data. This problem would cause small errors in the forecast if the truncated wave has a small amplitude. However, if the amplitude of the truncated wave is large and if the wave does not complete even one cycle then the error in the forecast can be large.

To see how the program handles truncated waves, the test sample was used with NUMB = 44 and 52. For NUMB = 44 the longest waves completed only one and one half cycles. Table 4.1 shows how the values of MSEE changed with the forecast time for unsmoothed time-waves and smoothed (Smoother No. 2) time-waves. The values in this table show that smoothing the time-waves does reduce the error caused by wave truncation.

Table 4.1 also shows the values of the mean-square of estimate for forecast having a diagnostic data set length of fifty-two (i.e. NUMB = 52). The long time-waves in this data set only complete 1.7 cycles. Since the forecasts for NUMB = 44 and NUMB = 52 refer to





TABLE 4.1

## PROGRAM TEST USING SAMPLE DATA

| Forecast<br>Time ( $\frac{1}{2}$ days)                                                                                                                                                       | NUMB = 44          |                  | NUMB=52          |         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------|------------------|---------|
|                                                                                                                                                                                              | Unsmoothed<br>MSEE | Smoothed<br>MSEE | Smoothed<br>MSEE |         |
| 1                                                                                                                                                                                            | 42                 | 48               |                  |         |
| 2                                                                                                                                                                                            | 67                 | 49               |                  |         |
| 3                                                                                                                                                                                            | 106                | 30               |                  |         |
| 4                                                                                                                                                                                            | 62                 | 40               |                  |         |
| 5                                                                                                                                                                                            | 32                 | 27               |                  |         |
| 6                                                                                                                                                                                            | 14                 | 21               |                  |         |
| 7                                                                                                                                                                                            | 38                 | 30               |                  |         |
| 8                                                                                                                                                                                            | 16                 | 15               |                  |         |
| 9                                                                                                                                                                                            | 53                 | 26               | 26               | 1       |
| 10                                                                                                                                                                                           | 21                 | 10               | 29               | 2       |
| 11                                                                                                                                                                                           | 73                 | 25               | 13               | 3       |
| 12                                                                                                                                                                                           | 67                 | 15               | 14               | 4       |
| 13                                                                                                                                                                                           | 92                 | 12               | 23               | 5       |
| 14                                                                                                                                                                                           | 59                 | 8                | 15               | 6       |
| 15                                                                                                                                                                                           | 82                 | 17               | 30               | 7       |
| 16                                                                                                                                                                                           | 94                 | 34               | 8                | 8       |
| 17                                                                                                                                                                                           | 126                | 46               | 26               | 9       |
| 18                                                                                                                                                                                           | 86                 | 21               | 18               | 10      |
| 19                                                                                                                                                                                           | 62                 | 51               | 26               | 11      |
| AVERAGE                                                                                                                                                                                      | 60                 | 28               | 25               | 12      |
| Change of mean-square error of<br>estimate with forecast time, for<br>unsmoothed time-waves and smoothed<br>(Smoother No. 2) time-waves. For<br>these forecasts NWAWE = 11 and<br>JWAVE = 8. |                    |                  | 33               | 13      |
|                                                                                                                                                                                              |                    |                  | 34               | 14      |
|                                                                                                                                                                                              |                    |                  | 32               | 15      |
|                                                                                                                                                                                              |                    |                  | 44               | 16      |
|                                                                                                                                                                                              |                    |                  | 64               | 17      |
|                                                                                                                                                                                              |                    |                  | 26               | 18      |
|                                                                                                                                                                                              |                    |                  | 40               | 19      |
|                                                                                                                                                                                              |                    |                  | 28               | AVERAGE |



different times, the values in Table 4.1 are displaced so that they refer to the same times. For NUMB = 52, more data were available than for NUMB = 44. The MSEE values for these forecasts should be less than the values with NUMB = 44. This was not the case. Both sets of height forecasts used smoother option No. 2, both were variance adjusted, and both had mean MSEE = 28 for the first 19 forecasts made. This indicates that the smoothing process needs more data, say several more complete cycles, before a noticable increase of forecast accuracy can be obtained. The change from 1.5 to 1.7 cycles is not enough.

#### 4.4 Other Smoothing Methods

The smoothing options mentioned in Chapter 3 were not the only smoothing techniques tested with the test sample data. Several other methods that were tested are:

- 1) Smoother No. 2 with the variance not adjusted,
- 2) Smoother No. 2 with the variance not adjusted and the mean-square of the first smooth wave found by

$$\frac{AA(0) + AA(1) + AA(2)}{3}$$

where  $AA(0) = 0.00$ , always,

- 3) Smoother No. 2 with variance adjusted but first wave not smoothed,
- 4) Smoother No. 2 with all frequencies not weighted,



and 5) Smoother No. 2 with all frequencies not weighted and first time-wave not smoothed.

The results of these smoothing methods are shown in Appendix L. From these tests, it is clear that the following produced lower average MSEE values:

1) Variance equalization

2) Weighted frequencies

and 3) Smoothing first time-wave, using mean-square

$$\text{formula} = \frac{AA(1) + AA(2)}{2}$$



## CHAPTER 5

### RESULTS USING SOUTHERN DATA SET

#### 5.1 Testing the Trend

Part 1 of the program was used with various values of NUMB (i.e. diagnostic data sets of various lengths) to test the trend calculation. The trend equation tested was;

$$A0(t) = D + H \cos\left(\frac{2\pi t}{730}\right) + C \sin\left(\frac{2\pi t}{730}\right)$$

In Table 5.1, the values of the coefficients (D, H and C) are shown for each value of NUMB. It can be seen that the value of these coefficients approach limits as the value of NUMB increases. To see how stable these limits were for different samples of the Southern Data set, tests were made with NUMB kept constant at 256, but the starting and ending time of the diagnostic data adjusted. Table 5.2 shows the results for eight of these tests. The average value of the coefficients and the unbiased estimate of the standard deviation are shown below.

$$\begin{aligned} D &= 56.8 \pm 0.9 \text{ dam} \\ H &= -9.1 \pm 0.6 \text{ dam} \\ C &= -15.5 \pm 1.0 \text{ dam} \end{aligned}$$





Table 5.1. Coefficients of Trend Equation, Mean Deviation from Trend, and Unbiased Variance for Various Values of NUMB

| NUMB | D<br>dam | H<br>dam | C<br>dam | MEAN<br>dam | VARIANCE<br>(dam) <sup>2</sup> |
|------|----------|----------|----------|-------------|--------------------------------|
| 5    | 13.3     | 33.9     | 3.0      | 0.000       | 0.065                          |
| 10   | -148.9   | 196.3    | -1.4     | 0.000       | 0.096                          |
| 15   | -318.8   | 366.4    | -3.2     | 0.001       | 0.129                          |
| 20   | 234.3    | -186.3   | -31.4    | 0.000       | 0.546                          |
| 25   | 110.6    | -63.0    | -18.3    | 0.000       | 0.626                          |
| 30   | 19.7     | 27.8     | -10.6    | 0.000       | 0.661                          |
| 35   | 6.1      | 41.2     | -9.4     | 0.000       | 0.605                          |
| 40   | 32.9     | 23.5     | -11.6    | 0.000       | 0.539                          |
| 45   | 30.2     | 17.3     | -12.4    | 0.000       | 0.487                          |
| 50   | 35.3     | 12.2     | -13.2    | 0.000       | 0.439                          |
| 60   | 73.3     | -25.3    | -20.5    | 0.000       | 0.647                          |
| 65   | 89.8     | -41.6    | -24.2    | 0.000       | 1.150                          |
| 70   | 83.3     | -35.3    | -22.6    | 0.000       | 1.178                          |
| 75   | 77.5     | -29.6    | -21.1    | 0.000       | 1.148                          |
| 80   | 78.7     | -30.7    | -21.4    | 0.000       | 1.080                          |
| 85   | 76.7     | -28.8    | -20.8    | 0.000       | 1.022                          |
| 90   | 74.9     | -27.0    | -20.3    | 0.000       | 0.973                          |
| 95   | 72.4     | -24.6    | -19.5    | 0.000       | 0.942                          |
| 100  | 65.2     | -17.7    | -17.0    | 0.000       | 1.048                          |
| 105  | 59.0     | -11.8    | -14.8    | 0.000       | 1.134                          |
| 110  | 56.4     | -9.3     | -13.8    | 0.000       | 1.116                          |
| 120  | 50.4     | -3.6     | -11.3    | 0.000       | 1.186                          |
| 125  | 49.4     | -2.7     | -10.9    | -0.007      | 1.158                          |
| 130  | 49.2     | -2.5     | -10.8    | -0.012      | 1.118                          |
| 135  | 50.1     | -3.3     | -11.2    | -0.013      | 1.091                          |
| 140  | 51.1     | -4.2     | -11.7    | -0.015      | 1.070                          |
| 145  | 51.0     | -4.1     | -11.7    | -0.014      | 1.037                          |
| 150  | 50.6     | -3.8     | -11.5    | -0.013      | 1.014                          |
| 155  | 50.2     | -3.5     | -11.3    | -0.012      | 0.996                          |
| 160  | 49.9     | -3.2     | -11.1    | -0.011      | 0.973                          |
| 165  | 51.7     | -4.8     | -12.1    | -0.012      | 1.076                          |
| 170  | 53.3     | -6.2     | -13.0    | -0.012      | 1.097                          |
| 180  | 52.9     | -5.8     | -12.7    | -0.012      | 1.161                          |
| 200  | 54.2     | -6.9     | -13.7    | -0.010      | 1.579                          |
| 210  | 55.1     | -7.7     | -14.4    | -0.009      | 1.561                          |
| 240  | 58.4     | -10.3    | -17.0    | -0.006      | 1.748                          |
| 298  | 56.4     | -8.9     | -15.1    | 0.002       | 1.493                          |



Table 5.2 Values for Trend Coefficients  
for Different Samples which  
have the same value of NUMB

| End Point |     | D<br>dam | H<br>dam | C<br>dam |
|-----------|-----|----------|----------|----------|
| 1         | 257 | 57.8     | -9.9     | -16.5    |
| 10        | 266 | 57.8     | -9.8     | -16.4    |
| 20        | 276 | 57.6     | -9.5     | -16.3    |
| 30        | 286 | 56.8     | -9.1     | -15.5    |
| 40        | 296 | 56.8     | -8.9     | -15.5    |
| 50        | 306 | 56.7     | -8.7     | -15.5    |
| 60        | 316 | 56.2     | -8.4     | -14.8    |
| 70        | 326 | 55.0     | -8.5     | -13.5    |
| Average   |     | 56.8     | -9.1     | -15.5    |



The maximum deviation from the mean for any of these coefficients was 2 dam. However, a steady change in value of the coefficients was observed as the diagnostic data set was displaced in the direction of increasing time. Since the program only retains a maximum of 300 reports for diagnostic purposes, some method of storage of trend information was required to carry out a more stable coefficient calculation.

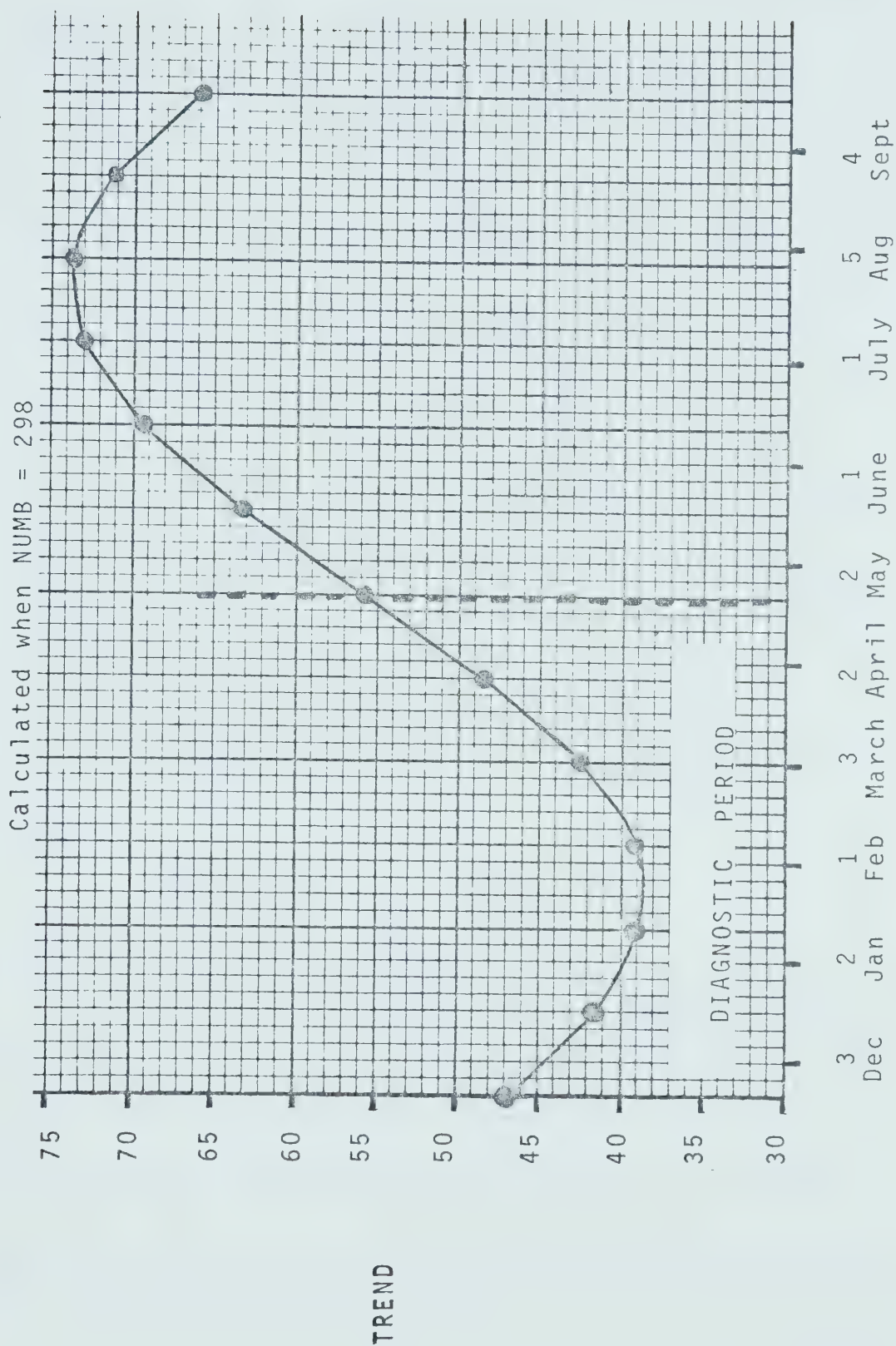
The method used in the program is to store the various parameters that are needed to calculate the coefficients D, H, and C. When new reports are read into the computer, the stored parameters are updated and then new coefficients are calculated.

Figure 5.1 shows the trend values calculated, when NUMB = 298. The maximum, indicated by the trend, occurred within two days of the actual maximum in the means and had a value within 1 dam of the actual maximum. The minimum value of the trend occurred during the diagnostic period and fit the means quite well. However, no statistics were calculated to indicate how well these trend values fit the means of all available reports.

Also, a comparison can be made of the trend curve, (Figure 5.1), and the curve for the net solar radiation arriving at the Earth's surface (see page 133 in Hess(1959)). The two curves appear to be highly correlated, with an estimated time lag of 25 days in



Figure 5.1. The Yearly Trend, of the Southern Data Set,







the trend curve. This correlation justifies the previous assumptions of a yearly trend.

Two statistics were calculated to indicate the trend values' goodness of fit to the means of the reports. These statistics were:

$$\text{the mean deviation from the trend MEAN} = \frac{1}{N} \sum_{i=1}^{\text{NUMB}} Z(t)$$

and the unbiased variance of the deviation around the trend

$$\text{Variance} = \frac{1}{\text{NUMB}-1} \sum_{i=1}^{\text{NUMB}} Z(t)^2$$

For this variance calculation it is assumed that the MEAN is equal to zero since the least-square fit minimizes this mean deviation squared. Also note that all data are used for trend calculation. Errors in the data set produced by estimating missing data report means, or any poor CMC analysis producing an abnormal mean are also used.\*

## 5.2 Forecasts of Height Reports

Forecasts were made with the three smoothing options previously mentioned (NO. 1, NO. 2 and NO. 3) and the unsmoothed option. Sixty forecasts were made, one every 12 hours. For the first 28 forecasts the average

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\* See Figure 1.1 for time 26.5 and 32.5 - Dec 20, 00Z and Dec 26, 00Z, 1976, respectively.



MSEE and average R were calculated. Since the use of two statistics made it hard to compare the accuracy of forecasts, a new statistic was defined.

$$r^* = \sqrt{(100\text{dam}(1-R))^2 + \text{MSEE}^2}$$

where  $r^*$  has units of decameters-squared.

Figure 5.2 shows the average R plotted against average MSEE for various forecasts. The lines go through  $R = 1$  and  $\text{MSEE} = 0$ . Also, they go through the mean value for the forecast made, having the same NUMB. The statistic  $r^*$  represents the "distance" of the forecast values of average R and average MSEE from  $R = 1.00$  and  $\text{MSEE} = 0.00$ . Table 5.3 shows these values of  $r^*$  for the various forecasts. See Appendix M for actual forecast results.

### 5.3 Observations

As expected, the persistence forecasts give the best results over periods of 12 to 36 hours. However, persistence forecasts generally give poor results for periods beyond 36 hours. Also, from Figure 5.2, it can be seen that the persistence forecasts have slightly higher correlation with the actual heights than would be predicted from the line through the means of forecasts. The persistence values also indicated how rapid the height field changed during the forecast period (large  $r^*$  indicating rapid change).



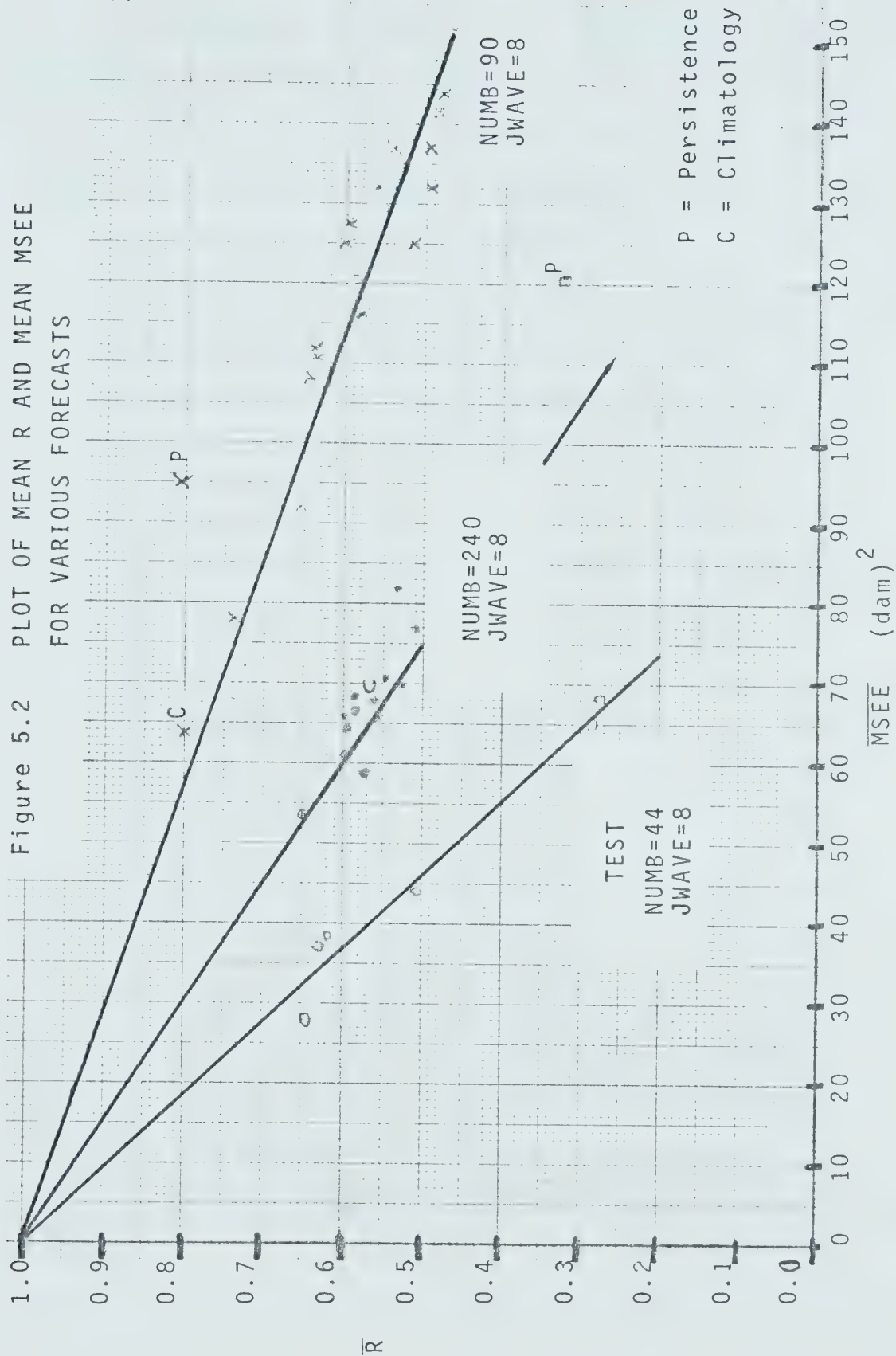
Table 5.3. The Values of  $r^*$  Determined From the First 28 Forecasts, for Various Forecast Options

| NUMB | Smoother<br>Used | JWAVE = 8 |      |      |     |     |     |     | Persistence | Climatology |  |
|------|------------------|-----------|------|------|-----|-----|-----|-----|-------------|-------------|--|
|      |                  | NWAVE     |      |      |     |     |     |     |             |             |  |
|      |                  | 1         | 2    | 3    | 4   | 5   | 6   | 11  |             |             |  |
| 60   | NONE             |           |      |      |     |     |     | 157 |             |             |  |
|      | 2                |           |      |      |     |     |     | 124 |             |             |  |
| 90   | NONE             | 98        | 125  | 134  | 141 | 146 | 151 | 153 | 97          | 67          |  |
|      | 1                |           |      |      |     |     | 139 |     |             |             |  |
|      | 2                | 82        | 118  | 114  | 117 |     | 132 | 133 |             |             |  |
|      | 3                |           |      | 127  |     |     | 143 |     |             |             |  |
| 240  | NONE             | 72        | 73   | 84   |     |     |     |     | 138         | 81          |  |
|      | 1                | 78        |      |      | 94  |     |     |     |             |             |  |
|      | 2                | 73        | 84   |      | 91  |     |     |     |             |             |  |
|      | 3                | 64        | 76   | 79   | 80  | 81  |     |     |             |             |  |
|      |                  | NWAVE = 2 |      |      |     |     |     |     |             |             |  |
|      |                  | JWAVE     |      |      |     |     |     |     |             |             |  |
|      |                  | 5         | 8    | 11   |     |     |     |     |             |             |  |
| 240  | 3                | 74.8      | 76.4 | 76.5 |     |     |     |     |             |             |  |

Where: NUMB = Size of diagnostic data set  
 NWAVE = Number of time-waves used  
 and JWAVE = Number of space-waves used.



Figure 5.2 PLOT OF MEAN R AND MEAN MSE  
FOR VARIOUS FORECASTS







Values of  $R$  and MSEE for climatology forecasts indicate how rapidly the height field changes compared to the average over the diagnostic period. For a small diagnostic data set ( $NUMB = 90$ ) the climatology results over the first twenty-eight forecasts had a lower  $r^*$  than the forecasts using the larger diagnostic data set ( $NUMB = 240$ ). This is a similar characteristic to a persistence forecast since the "closer" diagnostic data set ( $NUMB = 90$ ) produced the better forecasts. Since the climatology forecast for the group,  $NUMB = 240$ , was poor (i.e.  $r^*$  large), then the forecasts with time added to climatology usually produced better forecasts (i.e.  $r^*$  small).

Looking at the  $R$  and MSEE values for the forecasts using time-waves, it can be seen that unsmoothed time-waves gave good results for the initial forecasts but gave bad results for later forecasts, a consequence of not tapering\*\* the diagnostic data set at the ends. On the other hand, the forecasts produced, using smoothed time-waves, had no preferred period for good or bad forecasts. This was due to the change of phase, amplitude and frequency produced by the smoothing options.

Usually the wave amplitude  $AAMPL(t,m)$  had one

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\*\* See Kanasewich(1975) page 98, for a description of tapering.



or two well-separated strong waves in the data (for  $m = \text{constant}$ ). The smoothing techniques, however, would cluster the smoothed waves (usually 3) around the frequency of each actual strong wave. When the program selected the three strongest time-waves, it usually got three smoothed time-waves that clustered around the strongest unsmoothed time-wave, and would not use any information from the second or third-strongest unsmoothed time-wave. The resultant wave amplitude produced from the combination of the three waves was larger than the original strong wave. The example below demonstrates this clustering in the smoothed waves.

Example: These data are taken from the computer printout using actual height and wave-amplitude data. NUMB = 240 and the amplitude  $\div 2$  being analyzed for time-waves were in AAMPL (t,3) (i.e. cosine component of space-wave number 3)

|                                             | Frequency<br>Cycles<br>per Hour | R<br>(dam) | Q<br>(degrees) | AA<br>(dam) <sup>2</sup> |
|---------------------------------------------|---------------------------------|------------|----------------|--------------------------|
| Actual<br>Waves                             | .00208                          | .067       | -101           | .00907                   |
|                                             | .00243**                        | .530       | 76             | .56185                   |
|                                             | .00278                          | .207       | 130            | .08642                   |
| Smoothed<br>Waves<br>(Smoother<br>Number 3) | .00233                          | .3587      | 79             | .25729                   |
|                                             | .00247                          | .3519      | 90             | .24767                   |
|                                             | .00260                          | .3955      | 105            | .31286                   |

\*\* Frequency of wave with large amplitude, around which the smooth waves cluster



For this example, the maximum amplitude that these three waves can obtain, if constructive interference occurred, would be 1.6 dam for the actual wave and 2.1 for the smooth wave. This error in the amplitude in AAMPL, would produce a height error introduced not only by a phase-change, but also by an amplitude change in the space-wave. The program can't discriminate between the frequencies of the sorted strong wave. Therefore, it can't skip from one set of clustered frequencies to another to use as much information as is available.

Changes in the number of space-waves (JWAVE) used to produce the height forecasts appeared to produce only a slight change in accuracy of the forecasts (see bottom part of Table 5.3). For small JWAVE, an improvement was seen in the forecasts. Also, as the diagnostic data set size (NUMB) increased, a slight improvement was noted in the forecasts. This is indicated in Figure 5.2 by the grouping of the forecasts closer to a perfect forecast ( $R-1$ ,  $MSEE = 0$ ).



## CHAPTER 6

### RESULTS USING THE NORTHERN DATA SET

#### 6.1 Trend Calculations

The trend coefficients D, H and C, were poorly defined for the Northern Data Set. Table 6.1 shows that the values of the coefficients continued to fluctuate even when the diagnostic data set was large. This lack of stability was due to the large and rapid fluctuations in the means of the height sets (See Figure 6.1). The diagnostic data set covered the period Dec 1, 00Z, 1976, to March 30, 12Z, 1977. In this latitude belt this is winter and, as expected, the heights are consistently low. It also meant that no noticeable spring warming had occurred as yet. The resultant trend was quite flat, but did indicate a minimum mean around day 80 (Feb 18). This is slightly later than the date of the minimum in the Southern Data set, and supports the assumption that the trend is produced by solar heating.

#### 6.2 Observations

The program operated on the Northern Data set without any modifications. Unfortunately, the forecasts





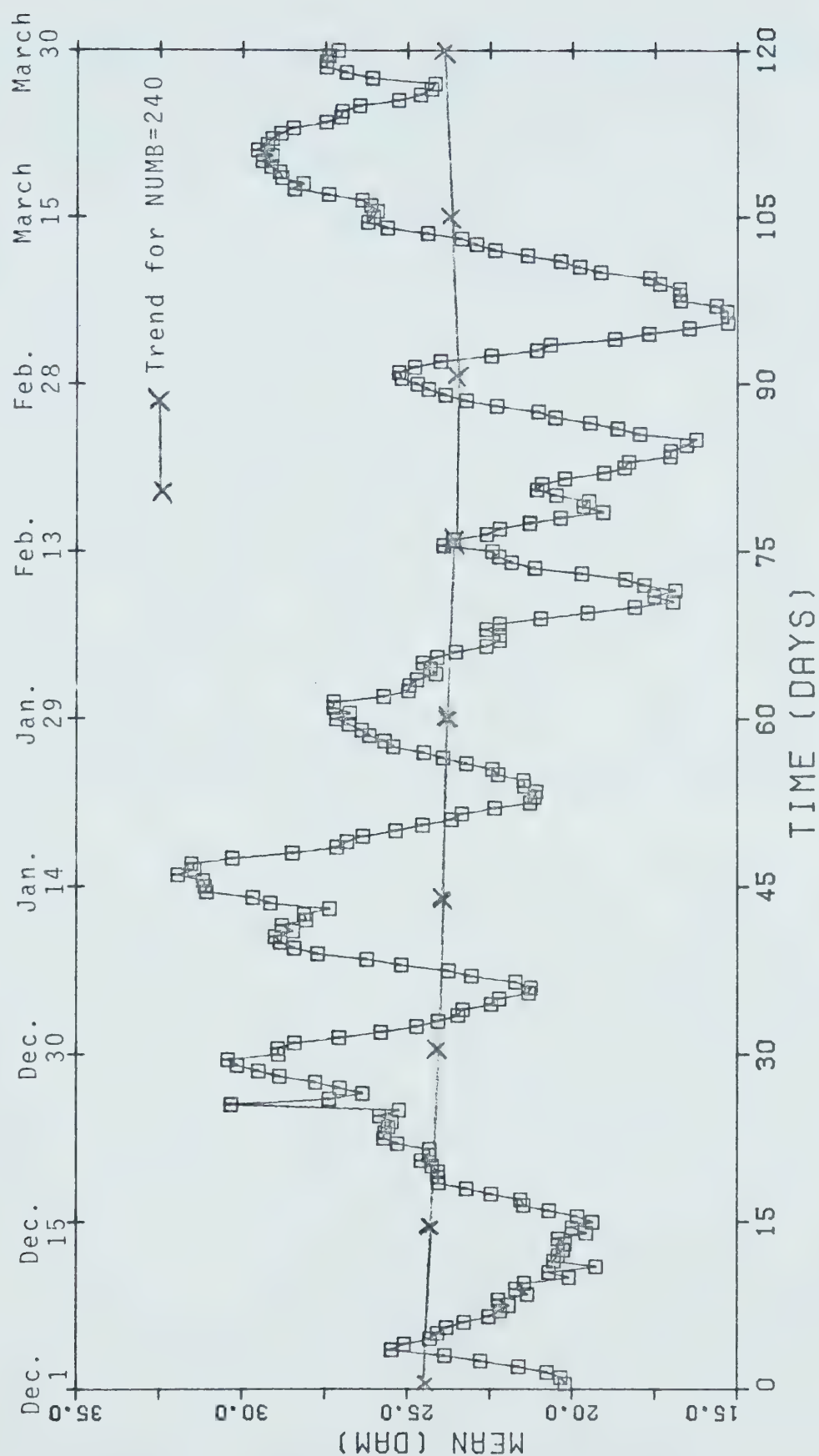
Table 6.1. Values of Trend Coefficients and Mean and Variance Around the Trend, for Various Values of NUMB.

| NUMB | D<br>(dam) | H<br>(dam) | C<br>(dam) | MEAN   | VARIANCE |
|------|------------|------------|------------|--------|----------|
| 5    | 66.7       | -47.5      | 73.3       | 0.000  | 0.107    |
| 10   | 110.6      | -91.8      | 93.6       | 0.000  | 0.192    |
| 15   | -1232.9    | 1252.4     | 102.8      | 0.060  | 0.733    |
| 20   | -907.1     | 927.1      | 81.2       | 0.065  | 0.791    |
| 25   | -258.6     | 280.5      | 21.0       | 0.124  | 1.544    |
| 30   | -196.0     | 217.9      | 16.6       | 0.113  | 1.466    |
| 35   | 0.7        | 21.9       | -4.8       | 0.095  | 2.054    |
| 40   | 132.5      | -109.4     | -20.8      | 0.091  | 2.485    |
| 45   | 183.7      | -160.2     | -27.9      | 0.106  | 2.325    |
| 50   | 177.1      | -153.7     | -26.8      | 0.095  | 2.131    |
| 60   | 174.2      | -151.0     | -25.6      | 0.078  | 2.092    |
| 70   | 41.6       | -20.5      | 4.9        | 0.045  | 5.502    |
| 80   | 13.0       | 7.5        | 11.7       | 0.035  | 6.237    |
| 90   | 32.4       | -11.4      | 6.0        | 0.045  | 5.872    |
| 100  | 29.0       | -8.1       | 7.3        | 0.058  | 6.025    |
| 110  | -4.1       | 23.6       | 19.4       | 0.083  | 7.861    |
| 120  | -0.2       | 19.9       | 17.7       | -0.013 | 7.546    |
| 130  | 1.0        | 18.8       | 17.3       | -0.007 | 7.063    |
| 140  | -5.3       | 24.6       | 20.2       | 0.016  | 6.885    |
| 150  | -8.6       | 27.7       | 21.8       | 0.019  | 7.040    |
| 160  | -5.0       | 24.4       | 19.9       | 0.006  | 6.885    |
| 170  | -4.8       | 24.2       | 18.8       | 0.005  | 6.566    |
| 180  | 1.6        | 18.6       | 15.8       | -0.003 | 7.543    |
| 190  | 6.2        | 14.7       | 12.9       | -0.011 | 8.271    |
| 200  | 5.6        | 15.2       | 13.3       | -0.010 | 8.007    |
| 210  | 11.5       | 10.3       | 9.0        | -0.009 | 9.778    |
| 220  | 18.1       | 5.0        | 3.9        | 0.030  | 12.964   |
| 230  | 22.9       | 1.2        | 0.1        | 0.024  | 14.412   |
| 240  | 24.8       | -0.2       | -1.5       | 0.023  | 14.247   |

Northern Data Set



Figure 6.1. Means of Reports and Trend for the Period December 1 00Z, 1976 to March 30 12Z, 1977.





did not verify as well as did those of the Southern Data set. Table 6.2 gives the values of  $r^*$  for several forecast options. These values are at least twice as large as those for the Southern Data set. Smoother No. 3 showed "increased skill" compared to the Climatology and Persistence forecasts while the unsmoothed time-waves showed "reduced skill".\*

Part of the forecast error was due to a spring pattern shift, as can be seen in Figure 6.2. The trough near 100W longitude starts to break down and to drift eastward. However, some of the error was due to a poor trend calculation. The error in the mean started at 3 dam and increased to 8 dam after 28 forecasts, and to 15 dam by the end of the 60-report (30 day) forecast period.

The amplitudes of the waves (see Figure 6.3) were also larger in the Northern Data set than in the Southern set. The space-waves with wave numbers 1 and 2 were still the most important and had amplitudes as large as 20 dam. The wave amplitudes decrease as wave numbers increase so that the amplitudes are generally below 5 dam once the wave number is greater than five. For any constant wave number, the time fluctuations of amplitude indicates long time-waves that might be resolved in a larger data set.

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\* See Appendix N for actual forecast results.



Table 6.2. Statistics for Various Forecasts Made  
Using the Northern Data Set with  
NUMB = 240 and JWAVE = 8

|             | Smoother | NWAVE | $\bar{R}$ | $\overline{MSEE}$ | $r^*$ |
|-------------|----------|-------|-----------|-------------------|-------|
| Persistence | --       | --    | 0.323     | 126.9             | 143.8 |
| Climatology | --       | --    | 0.491     | 127.9             | 137.7 |
|             | NONE     | 2     | 0.482     | 137.1             | 146.6 |
|             |          | 3     | 0.447     | 183.0             | 191.2 |
|             | 3        | 1     | 0.483     | 111.3             | 122.7 |
|             |          | 3     | 0.480     | 108.1             | 120.0 |
|             |          | 5     | 0.488     | 116.0             | 126.8 |
|             |          | 7     | 0.342     | 144.9             | 159.1 |





Figure 6.2. Hovmöller Diagram for the Period April 1 to 30, 1977  
(Northern Data Set)

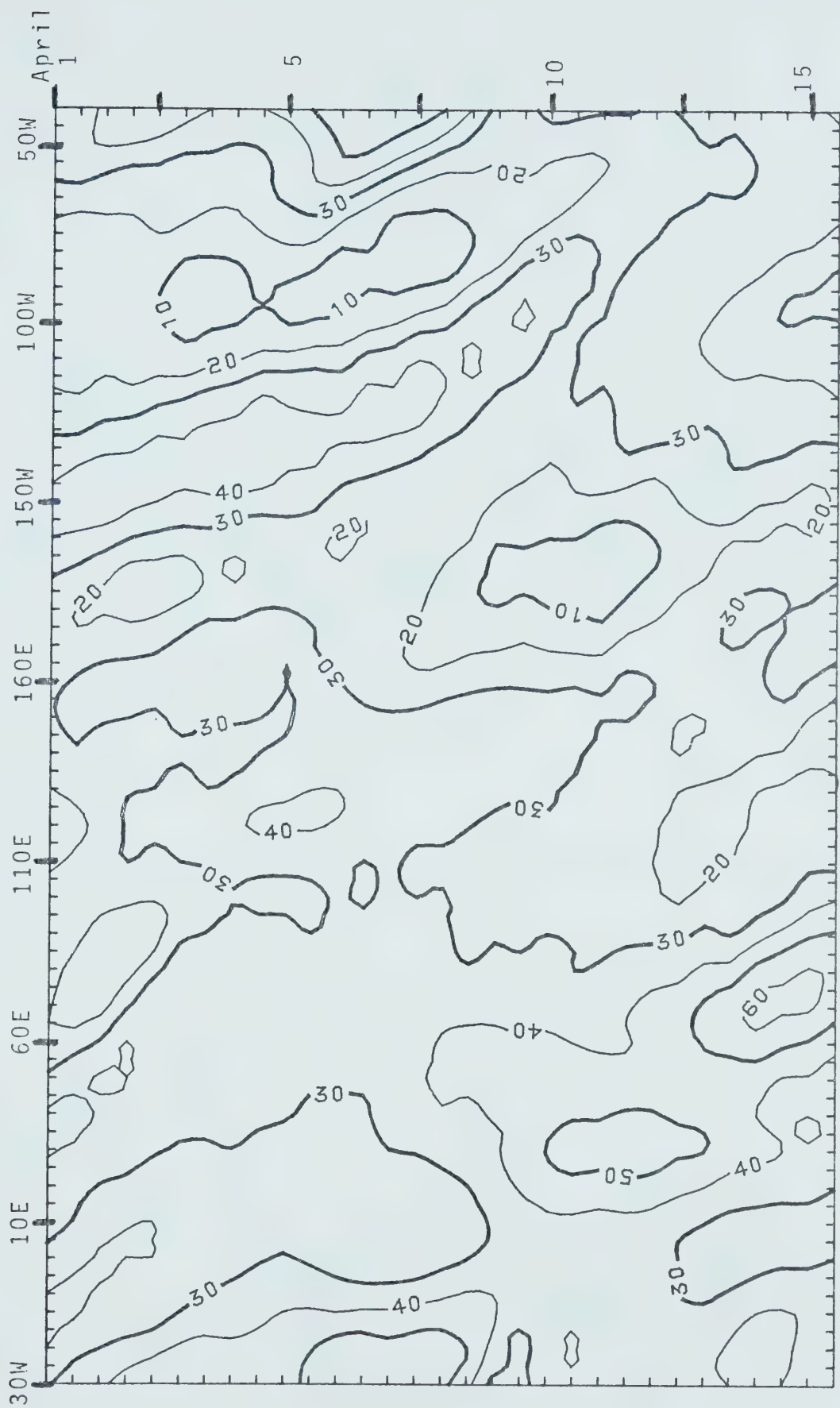
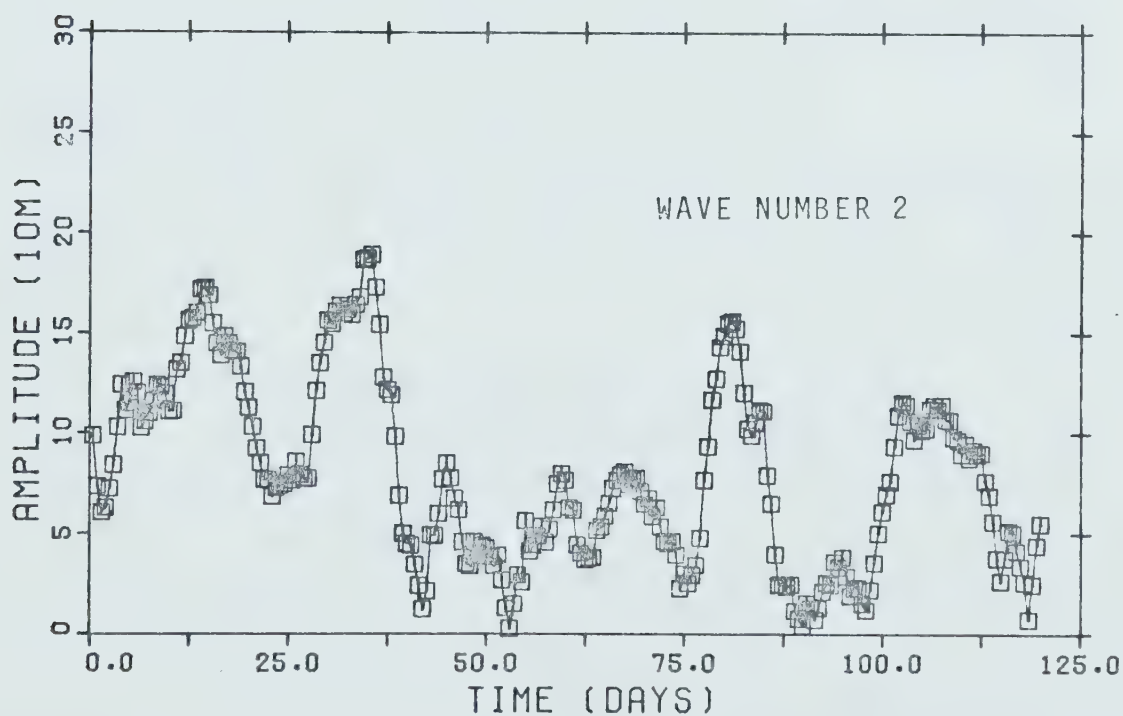
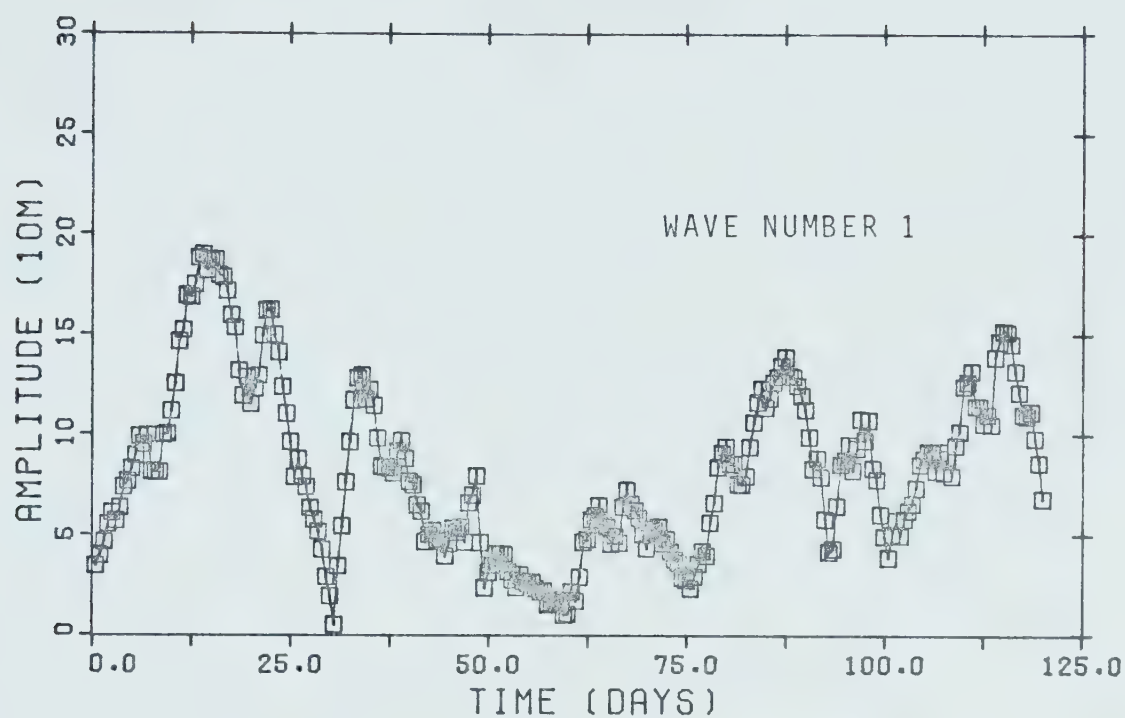




Figure 6.3. Plots of Amplitude Versus Time  
for Two Space-waves.  
Northern Data Set





## CHAPTER 7

### CONCLUSION

#### 7.1 Summary of Results

Figure 7.1 shows the actual Hovmöller Diagram and Figure 7.2 shows the forecast diagram for the period March 23, 12Z to April 7, 12Z 1977, using the Southern Data set. The forecast was made with Smoother No. 3, NUMB = 240, JWAVE = 11, and NWAVE = 2. These diagrams are strikingly different. The forecast diagram is quite smooth, with the forecast ridges and troughs showing some resemblance to the actual ridges and troughs. However, this resemblance is not good enough to be used to make operational weather forecasts.

This forecast diagram does show some skill since it indicates three interesting features. These are:

- 1) a stationary ridge along  $140^{\circ}\text{W}$ ,
- 2) a retrogressing ridge along  $40^{\circ}\text{E}$ ,
- and 3) a trough that splits into two troughs along  $140^{\circ}\text{E}$ .

As stated above, these features are slightly correlated with the actual height changes.

One of the things that is not observed in Figure 7.2 is the energy pulse. This might be due to



Figure 7.1. Hovmöller Diagram for March 23 12Z to April 7 12Z, 1977  
(Southern Data Set)

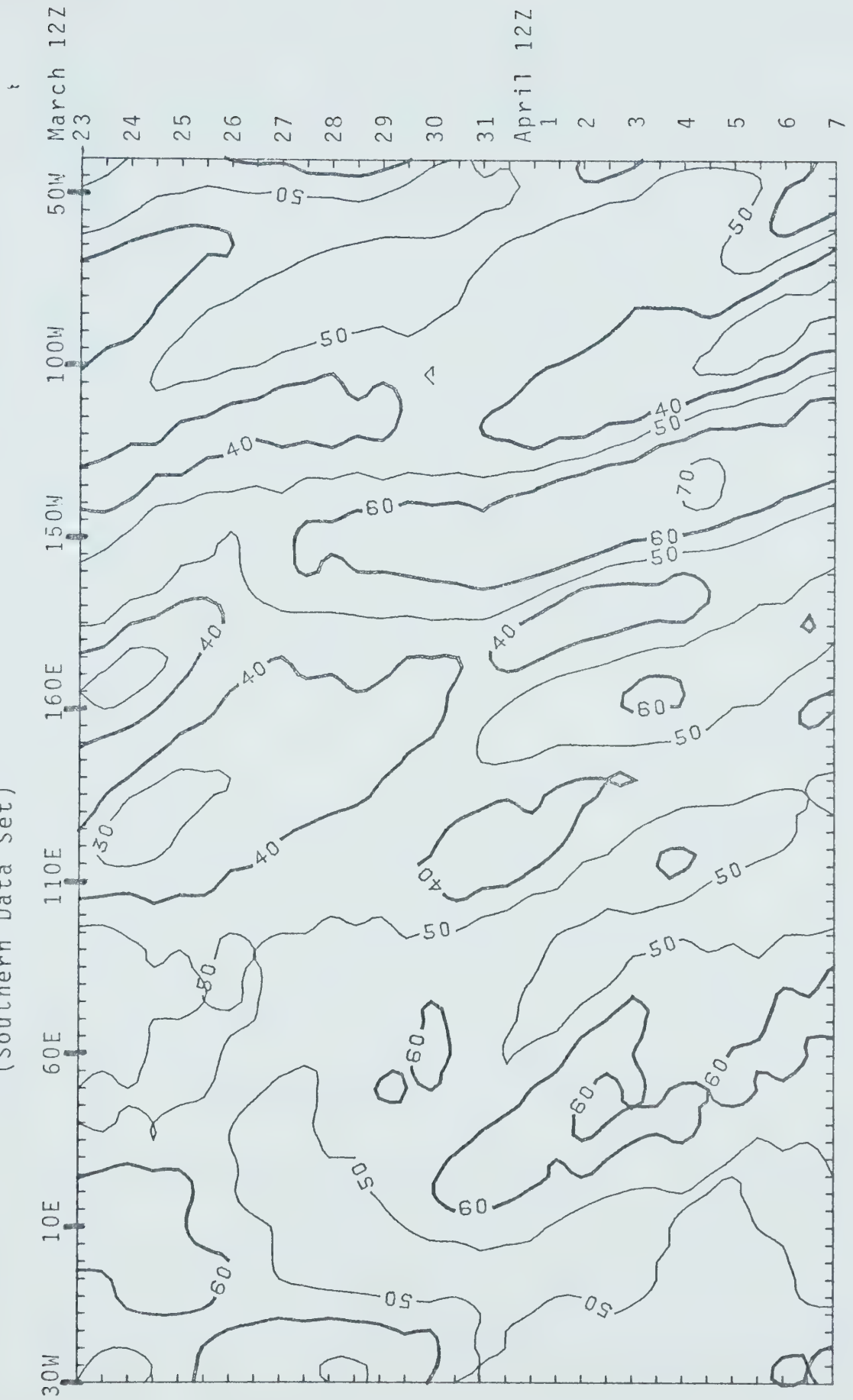
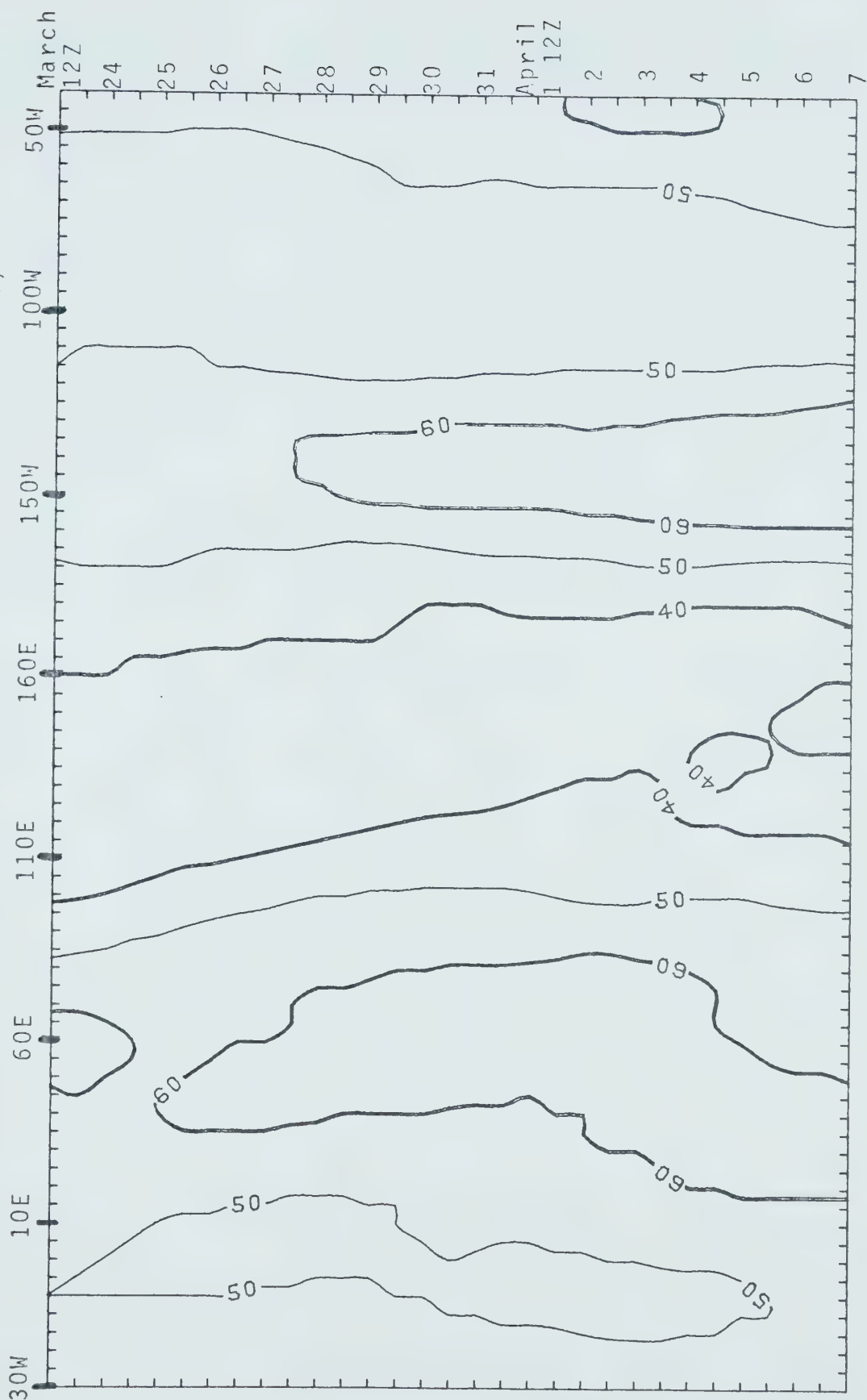






Figure 7.2. Forecast Diagram for Period of Figure 7.1 (Southern Data Set)  
 (JWAVE = 11, NWAVE = 2, NUMB = 240, and Smoother NO. 3)





the small number of time-waves used (NWAVE = 2); however, the use of more time waves produced smaller average correlation coefficients.

## 7.2 Future Studies

Orcheski is currently studying the results of converting the 500-mb height data that are presented in a Hovmöller Diagram. He first converts the data to "standardized" form. That is, for a report with elements  $X_i$ , a mean  $A_0$  and variance  $\sigma^2$ , the converted standardized report has elements  $\frac{X_i - A_0}{\sigma^2}$ , a mean of zero, and a variance of 1.00. The resulting data are then presented in the usual Hovmöller type diagrams.

Using this procedure, he has found that ridges and troughs appear more distinct. Also, a diurnal cycle is easily observed in the data throughout the year.

The height forecast program can be used to check if the standardization of the data produces better forecasts than the actual data. Better results are expected for forecasts of the standardized data since some of the "noise" would be removed. Also, since no trend would be observed, the error produced by the mean calculation would be removed. However, to reconvert the standardized data to 500-mb heights, the mean and the variance would also have to be forecast. The net effect



on forecast accuracy would have to be determined by experiments.

### 7.3 Larger Data Sets

The forecasts for the Southern Data set were good for NUMB = 240 and should get better as NUMB increases (maximum NUMB = 300). On the other hand, the forecasts for the Northern Data set were poor. To produce better forecasts a much larger data set is needed. From Figure 6.1, a long wave of period around 80 - 90 days, can be observed. This indicates that a Data Set close to one year in length (NUMB = 730) would be able to resolve this wave. The program would have to be adjusted to operate on such a large mass of data, but the results should be much better than those presented in this study.



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## APPENDIX A

Derivation of the equation for the phase speed  $V(m)$

Assume that the wave can be described by:

$$A(t)\cos(D(L,m)) + B(t)\sin(D(L,m))$$

$$A(t) = R_0 \cos(\phi(t))$$

$$B(t) = -R_0 \sin(\phi(t))$$

assume  $\phi = \phi_0 + V(t-t_0)$

where  $t_0, \phi_0$  refer to time zero (i.e.  $t_0 = 0$ )

therefore  $A(t) = R_0 \cos(\phi_0 + Vt)$

$$= R_0 \cos(\phi_0) \cos(Vt) - R_0 \sin(\phi_0) \sin(Vt)$$

and similarly

$$B(t) = -R_0 \sin(\phi_0) \cos(Vt) - R_0 \cos(\phi_0) \sin(Vt)$$

At  $t = t_0 = 0$

$$A(0) = R_0 \cos(\phi_0)$$

$$B(0) = -R_0 \sin(\phi_0)$$

therefore

$$A(t) = A_0 \cos(Vt) + B_0 \sin(Vt)$$

$$B(t) = B_0 \cos(Vt) - A_0 \sin(Vt)$$



Rearrange

$$\frac{A(t)}{B_0} = \frac{A_0}{B_0} \cos(Vt) + \sin(Vt)$$

$$\frac{B(t)}{A_0} = \frac{B_0}{A_0} \cos(Vt) - \sin(Vt)$$

therefore

$$\cos(Vt) = \left( \frac{A(t)}{B_0} + \frac{B(t)}{A_0} \right) / \left( \frac{A_0}{B_0} + \frac{B_0}{A_0} \right)$$

$$\cos(Vt) = \frac{A(t)A_0 + B(t)B_0}{A_0A_0 + B_0B_0}$$

similarly

$$\sin(Vt) = \frac{B_0A(t) - A_0B(t)}{A_0A_0 + B_0B_0}$$

therefore

$$V = \frac{1}{t} \arctangent \left( \frac{B_0A(t) - A_0B(t)}{B_0B(t) + A_0A(t)} \right)$$



## APPENDIX B

### TREND REMOVAL

Assume trend of form  $Y'(I)$  where

$$Y'(I) = D + H \cos(X) + C \sin(X)$$

and where  $X = \frac{I \cdot 2\pi}{730}$

so trend repeats after one year

therefore error =  $Y(I) - Y'(I)$

therefore use least-squared technique and minimize

$$\sum_{I=1}^N (Y(I) - Y'(I))^2$$

$$\begin{aligned} & (Y(I) - Y'(I))^2 \\ &= Y^2(I) - HY(I)\cos(X) - CY(I)\sin(X) - DY(I) - \\ & \quad HY(I)\cos(X) + H^2\cos^2(X) + HC\cos(X)\sin(X) \\ & \quad + DH\cos(X) - CY(I)\sin(X) + HC\cos(X)\sin(X) \\ & \quad + C^2\sin^2(X) + CD\sin(X) - DY(I) + HD\cos(X) \\ & \quad + CD\sin(X) + D^2 \\ &= \text{Quant} \end{aligned}$$





$$\begin{aligned}
&= D^2 + Y^2(I) - 2DY(I) + 2H(D-Y(I))\cos(X) + \\
&\quad 2C(D-Y(I))\sin(X) + H^2\cos^2(X) + C^2\sin^2(X) \\
&\quad + 2HC\cos(X)\sin(X)
\end{aligned}$$

take

$$\frac{\partial \text{Quant}}{\partial D}, \quad \frac{\partial \text{Quant}}{\partial H}, \quad \frac{\partial \text{Quant}}{\partial C} \quad \text{and set} = 0 \text{ for extremum}$$

$$\frac{\partial \text{Quant}}{\partial D} = 2D - 2Y(I) + 2H\cos(X) + 2C\sin(X) = 0$$

$$\begin{aligned}
\frac{\partial \text{Quant}}{\partial H} &= -2Y(I)\cos(X) + 2H\cos^2(X) + 2C\cos(X)\sin(X) \\
&\quad + 2D\cos(X) = 0
\end{aligned}$$

$$\begin{aligned}
\frac{\partial \text{Quant}}{\partial C} &= -2Y(I)\sin(X) + 2C\sin^2(X) + 2H\cos(X)\sin(X) \\
&\quad + 2D\sin(X) = 0
\end{aligned}$$

now added in  $\sum_{I=1}^N$

$$\begin{aligned}
1 \left\{ \begin{aligned}
&DN - \sum_{I=1}^N Y(I) + H \sum_{I=1}^N \cos(X) + C \sum_{I=1}^N \sin(X) = 0 \\
&-\sum_{I=1}^N Y(I)\cos(X) + H \sum_{I=1}^N \cos^2(X) + C \sum_{I=1}^N \cos(X)\sin(X) \\
&\quad + D \sum_{I=1}^N \cos(X) = 0 \\
&-\sum_{I=1}^N Y(I)\sin(X) + C \sum_{I=1}^N \sin^2(X) + H \sum_{I=1}^N \cos(X)\sin(X) \\
&\quad + D \sum_{I=1}^N \sin(X) = 0
\end{aligned} \right.
\end{aligned}$$



now if data equally spaced & completes one full period,

$$\sum \cos(X) = \sum \sin(X) = \sum \cos(X)\sin(X) = 0$$

$$\sum \cos^2(X) = \sum \sin^2(X) = \frac{N}{2}$$

and the problem reduces to a Fourier type solution for one wave

$$\text{mean: } D = \frac{1}{N} \sum_{I=1}^N Y(I)$$

$$\text{amplitudes: } H = \frac{2}{N} \sum_{I=1}^N Y(I)\cos(X)$$

$$C = \frac{2}{N} \sum_{I=1}^N Y(I)\sin(X)$$

However, if data not equally spaced and one period not fully completed then the sums must be calculated.

$$\text{Call } \sum_{I=1}^N \cos(X) = T \qquad \sum_{I=1}^N \sin(X) = W$$

$$\sum_{I=1}^N \cos^2(X) = P \qquad \sum_{I=1}^N \sin^2(X) = Q$$

$$\sum_{I=1}^N \cos(X)\sin(X) = S$$

$$\text{and } \sum_{I=1}^N Y(I)\cos(X) = E$$



$$\sum_{I=1}^N Y(I) \sin(X) = F$$

$$\sum_{I=1}^N Y(I) = G$$

The set of equations (1) then reduces to

$$\begin{bmatrix} P & S & T \\ S & Q & W \\ T & W & N \end{bmatrix} \begin{bmatrix} H \\ C \\ D \end{bmatrix} = \begin{bmatrix} E \\ F \\ G \end{bmatrix}$$

using the Gauss-Jordan technique, the solution for H, C AND D becomes:

$$D = \frac{(TE-PG)(S^2-PQ) - (TS-PW)(SE-PF)}{(S^2-PQ)(T^2-PN) - (TS-PW)(TS-PW)}$$

$$C = \{(SE - PF) - (ST-PW) D\} / (S^2-PQ)$$

$$H = (E - TD - SC) / P$$



## APPENDIX C

### (Southern Data Set)

Figure C.1 to C.11

Amplitude versus Time for space-waves of wave number 1 to 11, respectively. Time is indicated as days after November 23, 1976.

Table C.1

Values of AAMPL for NUMB = 240

Table C.2

Values of BAMPL for NUMB = 240





Figure C.1.

Wave Number 1

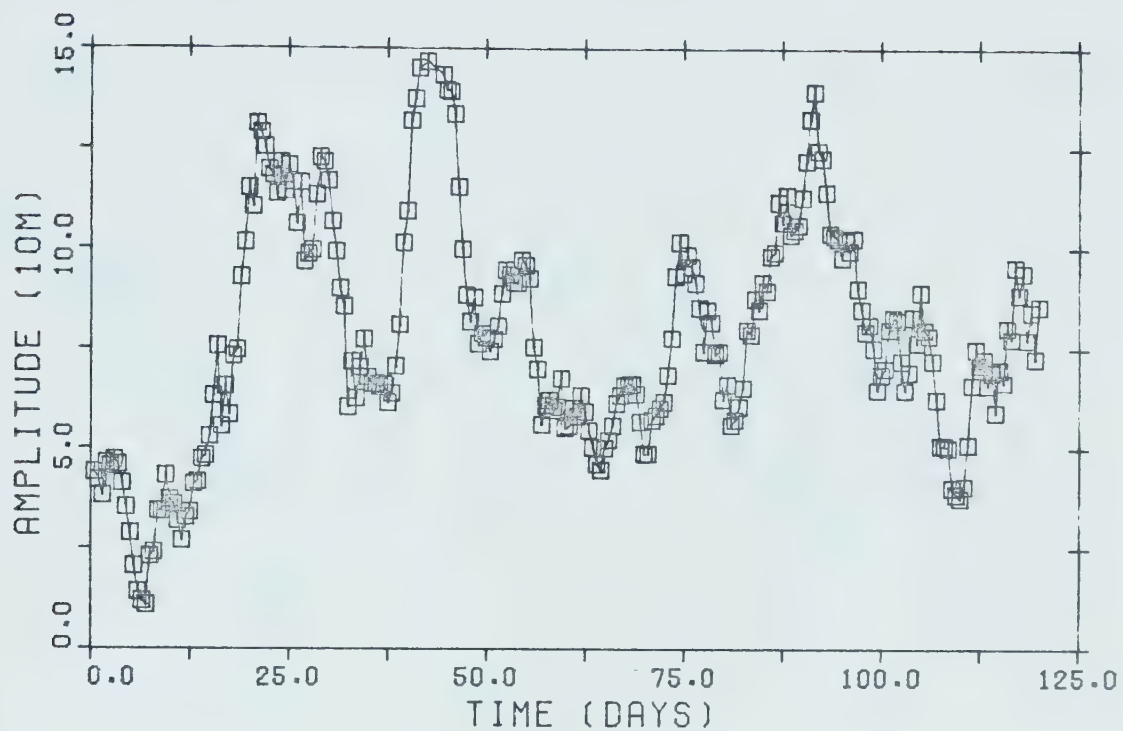


Figure C.2.

Wave Number 2

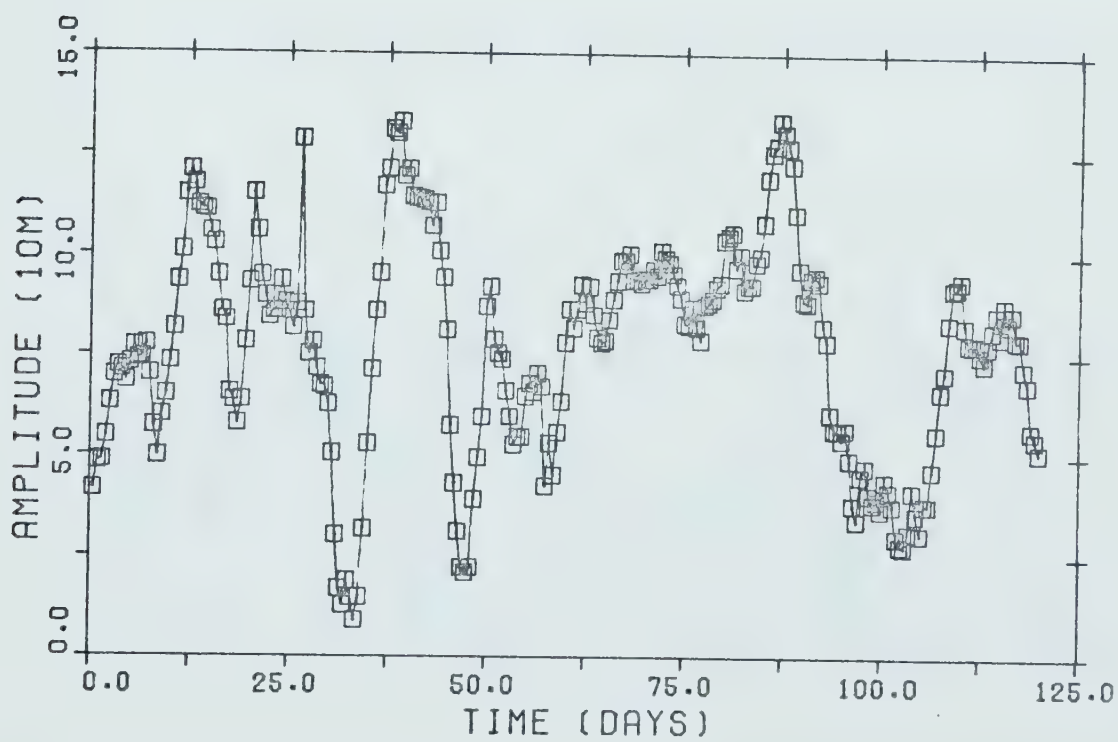




Figure C.3.

Wave Number 3

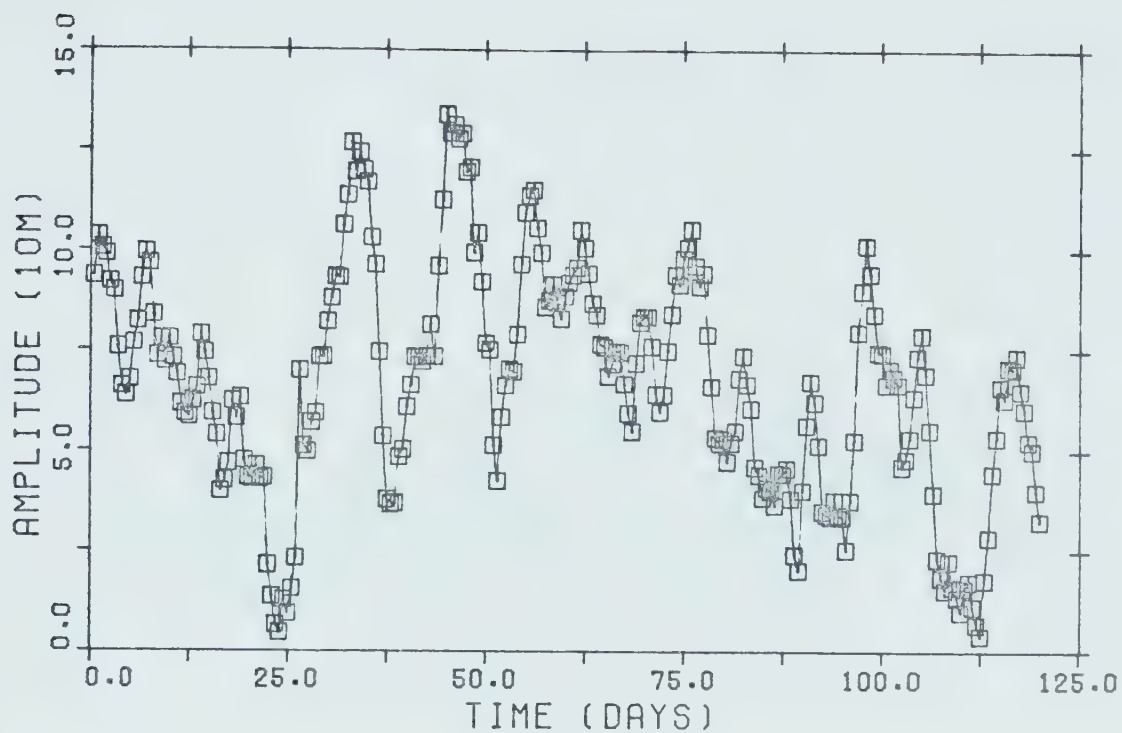


Figure C.4.

Wave Number 4

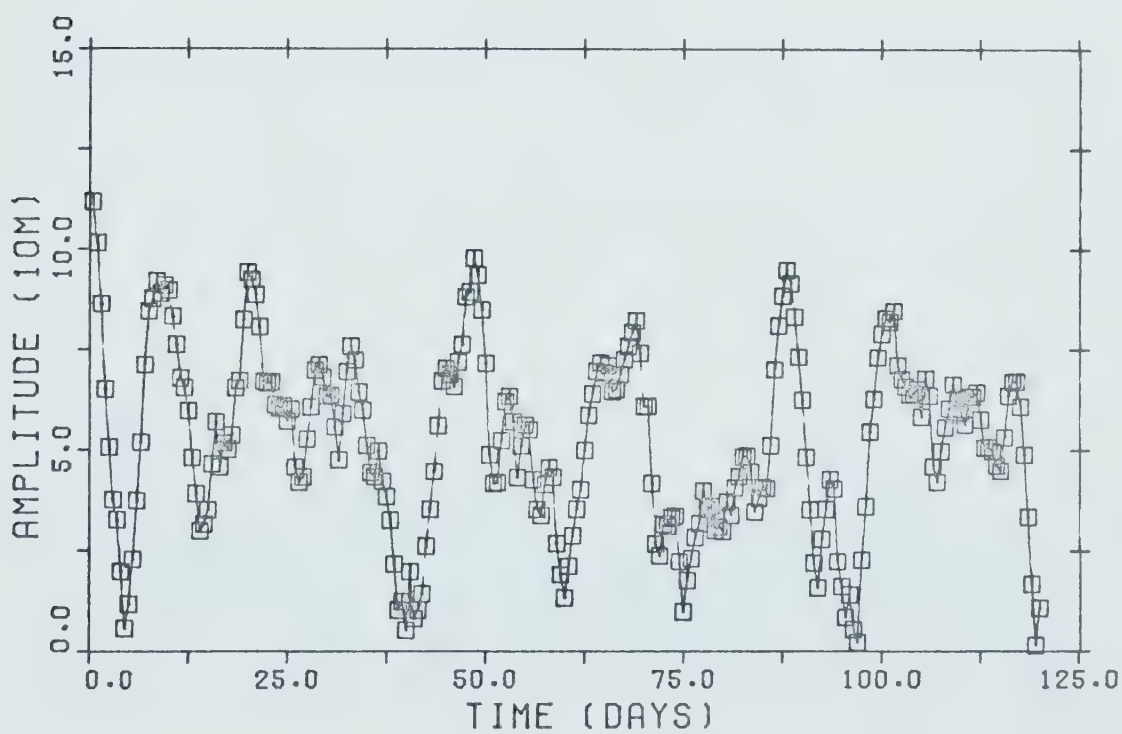




Figure C.5.

Wave Number 5

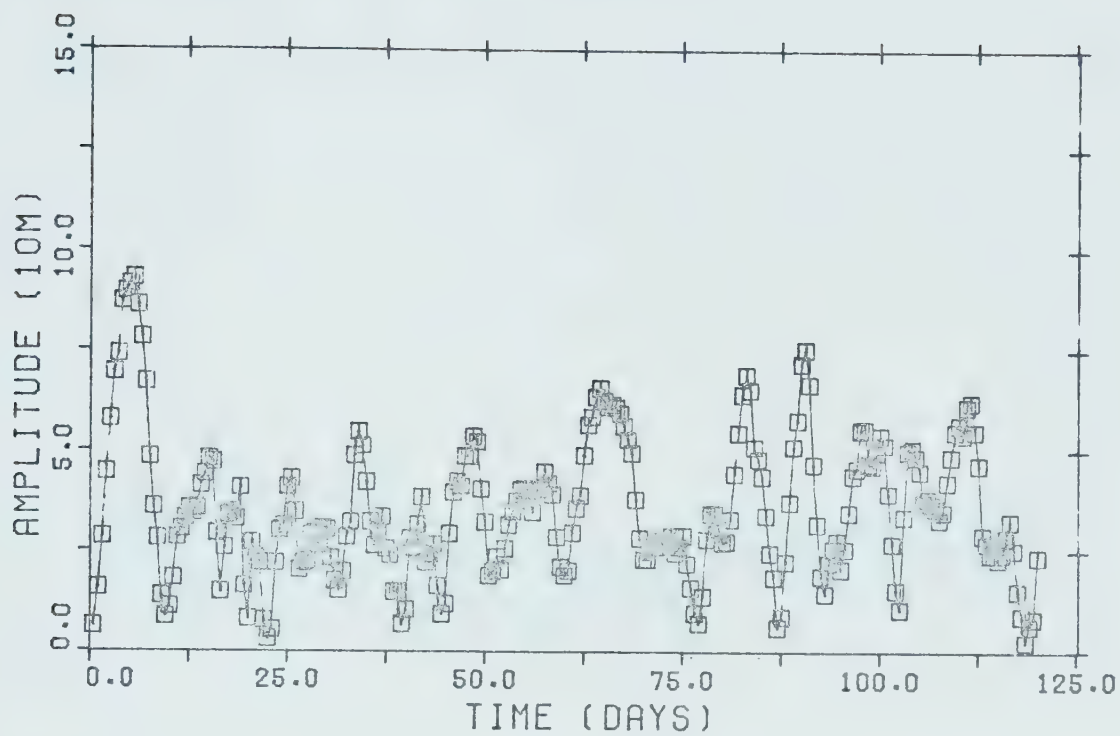


Figure C.6

Wave Number 6

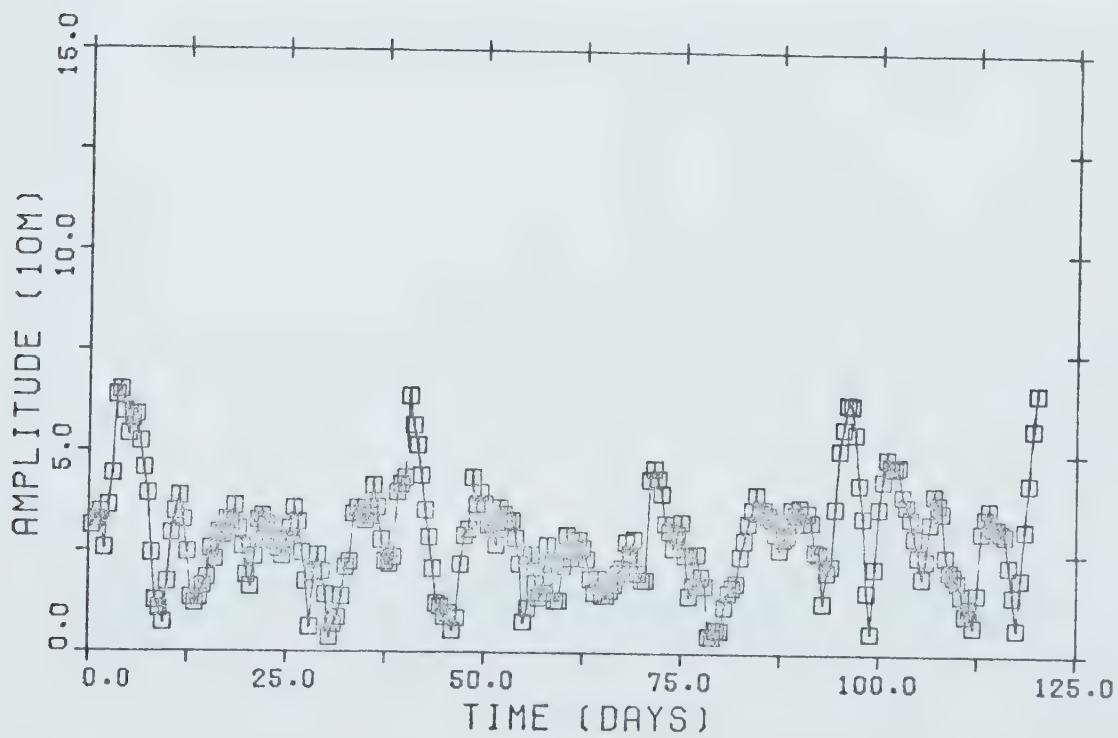




Figure C.7.

Wave Number 7

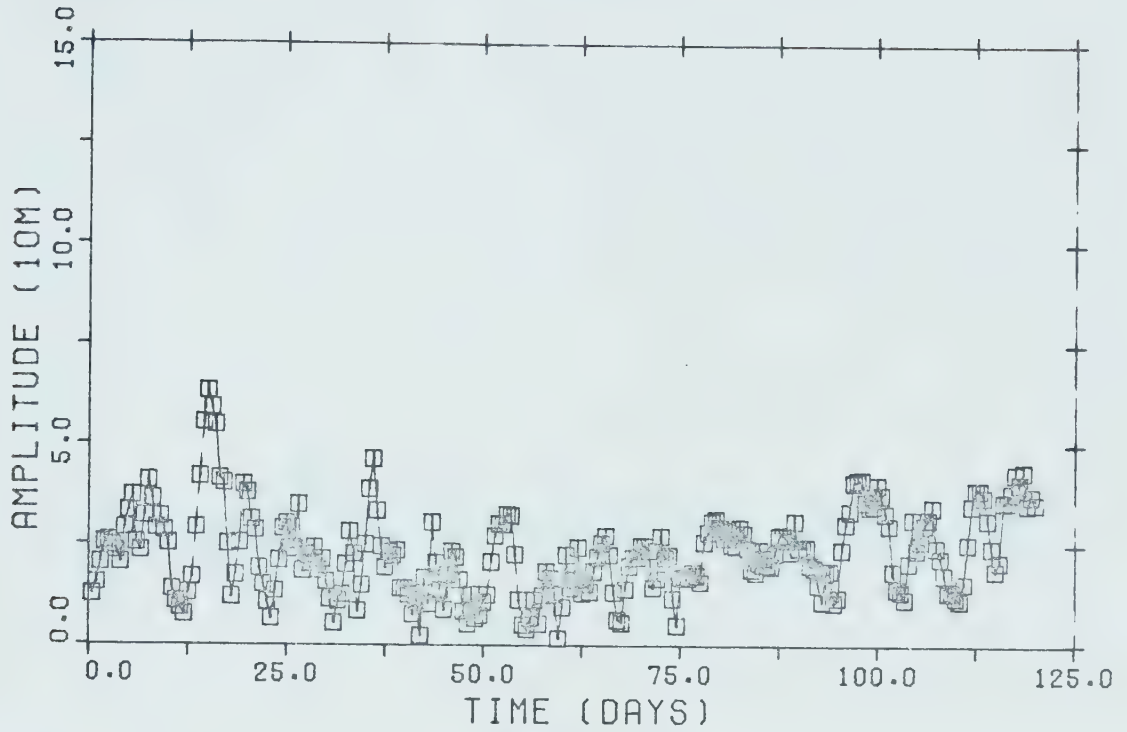


Figure C.8.

Wave Number 8

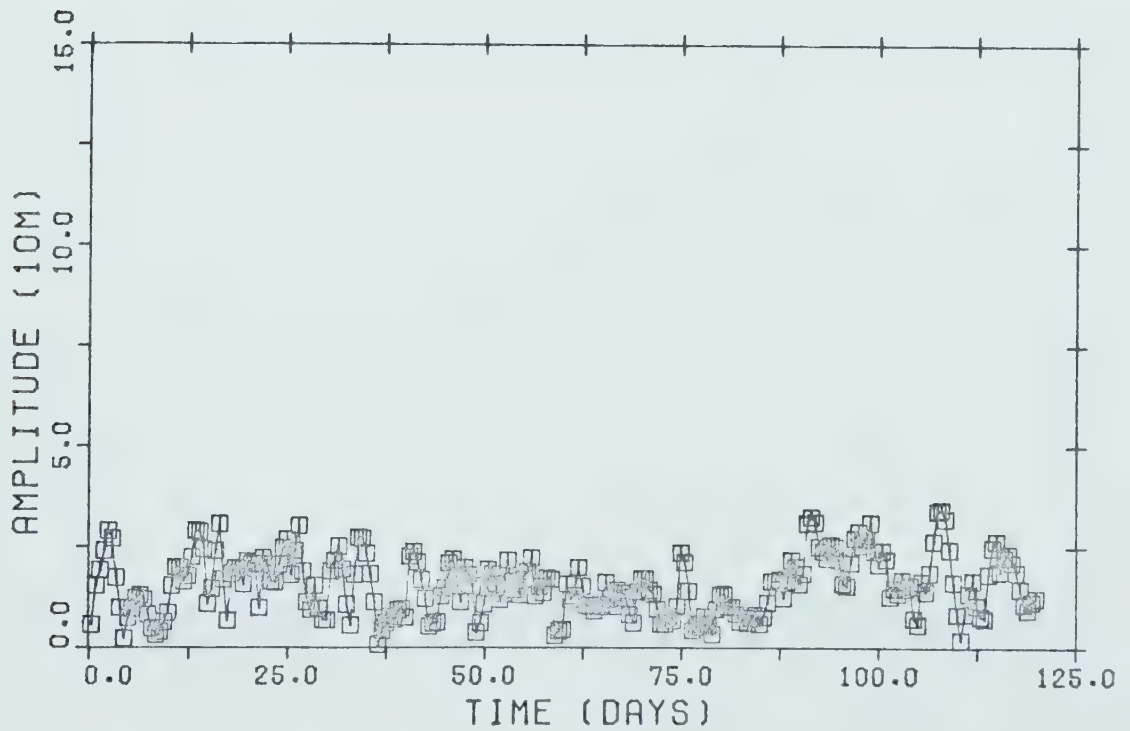






Figure C.9.

Wave Number 9

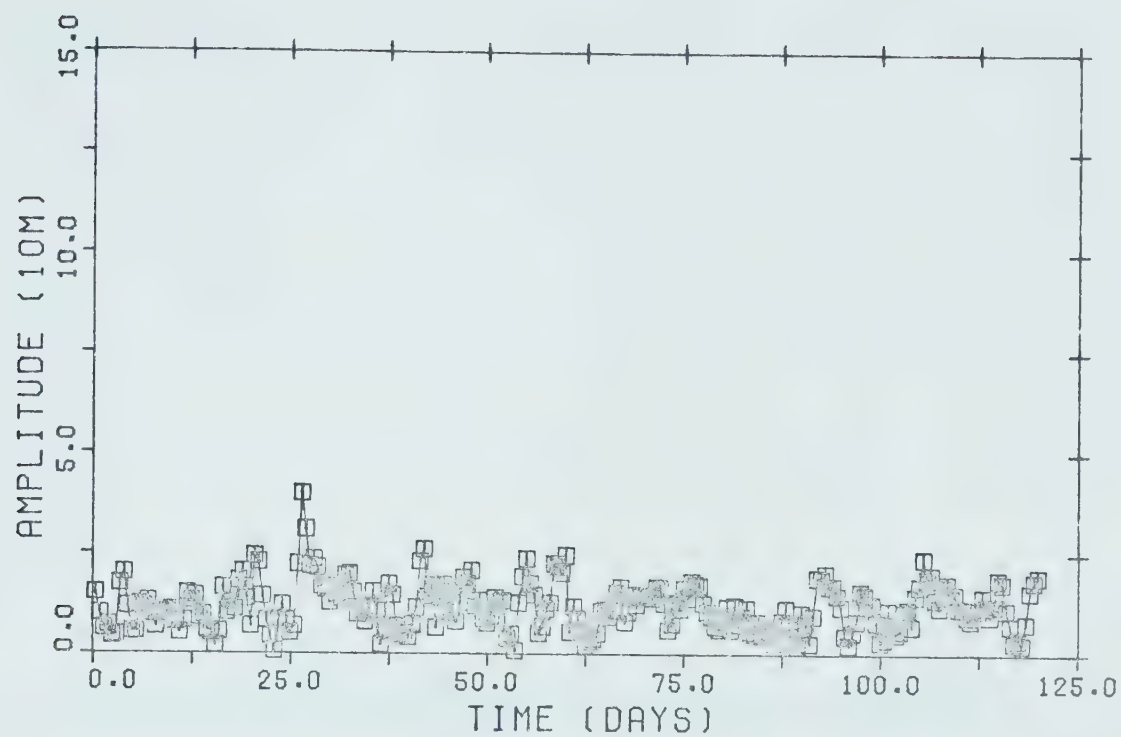


Figure C.10

Wave Number 10

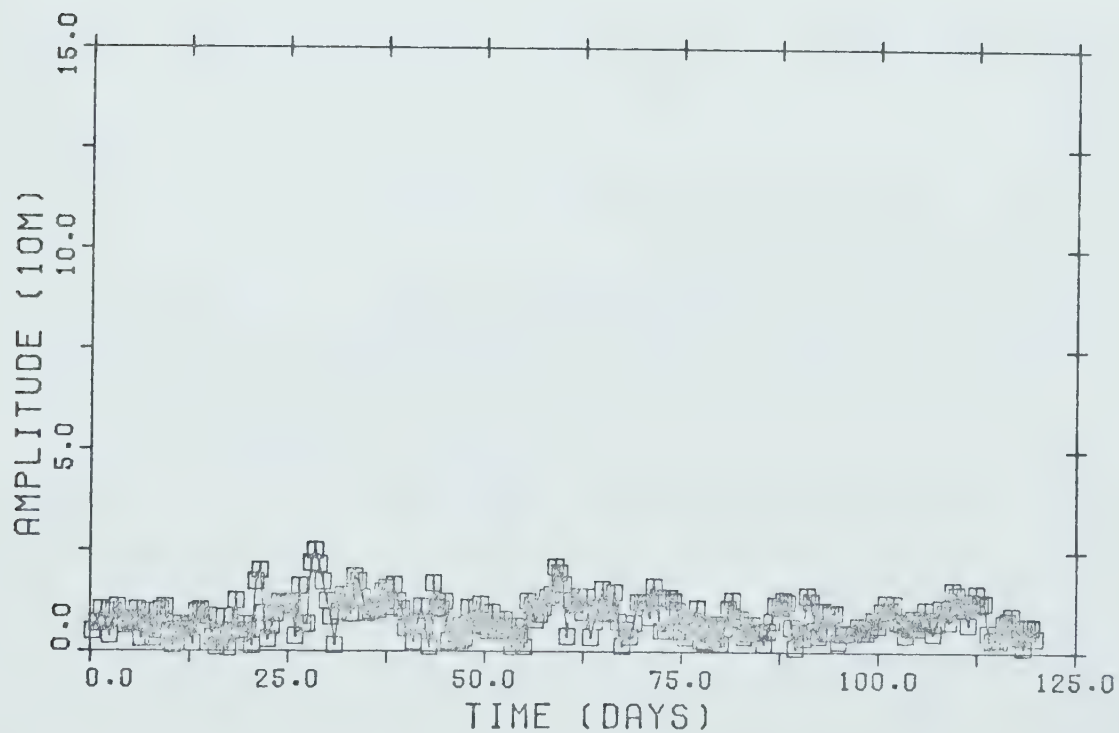




Figure C.11.

Wave Number 11

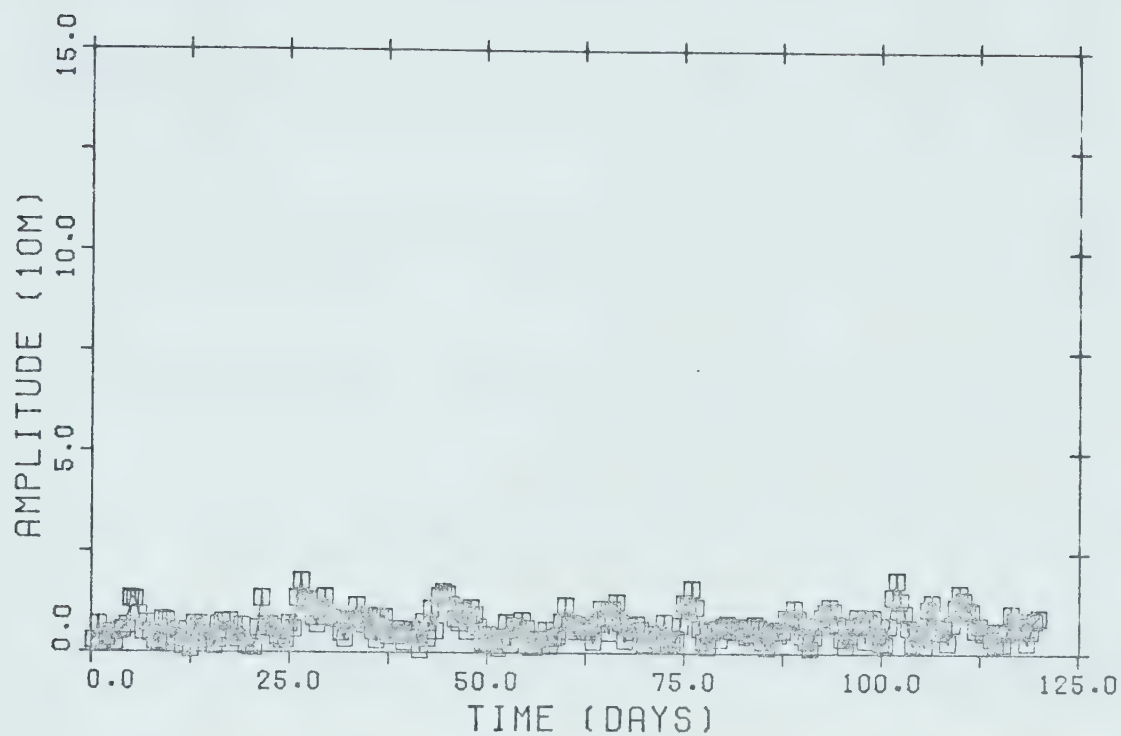




Table C.1. Values of AAMPL for NUMB = 240

| Row | Wave Number |       |       |      |       |       |       |       |       |       |       |
|-----|-------------|-------|-------|------|-------|-------|-------|-------|-------|-------|-------|
|     | 1           | 2     | 3     | 4    | 5     | 6     | 7     | 8     | 9     | 10    | 11    |
| 1   | -2.17       | -1.46 | -4.60 | 4.15 | 0.18  | -0.16 | 0.16  | -0.26 | -0.55 | 0.06  | 0.14  |
| 2   | -1.64       | -1.84 | -5.13 | 3.40 | 0.77  | -0.44 | 0.43  | -0.72 | -0.49 | -0.07 | 0.32  |
| 3   | -1.43       | -1.87 | -4.98 | 2.79 | 1.42  | -0.66 | 0.57  | -0.60 | -0.15 | 0.38  | 0.10  |
| 4   | -1.36       | -2.20 | -4.90 | 2.30 | 2.22  | -0.35 | 0.34  | -0.19 | 0.11  | 0.33  | 0.17  |
| 5   | -1.75       | -2.61 | -4.55 | 1.86 | 2.85  | -0.03 | -0.21 | 0.51  | 0.14  | 0.17  | 0.22  |
| 6   | -1.66       | -3.30 | -4.40 | 1.31 | 3.34  | 0.04  | -0.60 | 1.03  | -0.13 | 0.48  | 0.07  |
| 7   | -2.05       | -3.48 | -3.60 | 1.17 | 3.45  | -0.06 | -0.83 | 0.87  | 0.13  | 0.17  | -0.01 |
| 8   | -1.80       | -3.38 | -3.10 | 0.54 | 3.89  | -0.43 | -0.63 | 0.34  | 0.91  | -0.27 | 0.21  |
| 9   | -1.69       | -3.12 | -2.86 | 0.25 | 3.51  | -0.80 | -1.14 | -0.04 | 0.53  | -0.26 | -0.25 |
| 10  | -1.23       | -3.08 | -2.98 | -0.0 | 2.51  | -0.97 | -1.61 | 0.35  | 0.22  | 0.32  | 0.21  |
| 11  | -1.02       | -2.84 | -3.34 | 0.55 | 1.25  | -1.50 | -1.83 | 0.17  | 0.17  | 0.38  | 0.65  |
| 12  | -0.52       | -2.20 | -3.65 | 1.06 | 0.21  | -2.06 | -1.12 | -0.28 | -0.51 | 0.49  | 0.36  |
| 13  | -0.52       | -1.90 | -4.07 | 1.55 | -0.55 | -2.33 | -1.01 | -0.65 | -0.50 | 0.11  | 0.16  |
| 14  | -0.49       | -2.12 | -4.19 | 2.42 | -1.07 | -2.18 | -1.23 | -0.44 | -0.40 | 0.26  | 0.16  |
| 15  | -1.02       | -2.34 | -3.98 | 3.27 | -1.22 | -1.96 | -1.06 | 0.20  | -0.02 | 0.48  | -0.14 |
| 16  | -0.79       | -2.54 | -3.64 | 3.53 | -1.20 | -1.10 | -0.20 | 0.18  | -0.32 | 0.14  | -0.13 |
| 17  | -0.26       | -2.45 | -3.56 | 3.88 | -1.04 | -0.30 | 0.73  | 0.02  | -0.48 | 0.25  | 0.07  |
| 18  | 0.53        | -2.99 | -3.87 | 3.49 | -0.64 | 0.21  | 1.40  | -0.19 | 0.02  | 0.42  | -0.07 |
| 19  | 1.28        | -3.24 | -3.60 | 3.55 | -0.36 | 0.27  | 1.41  | -0.29 | 0.42  | 0.0   | -0.38 |
| 20  | 1.40        | -3.64 | -3.86 | 3.24 | -0.55 | 0.74  | 1.09  | 0.25  | 0.51  | -0.07 | -0.15 |
| 21  | 1.65        | -3.95 | -3.63 | 2.98 | -0.71 | 1.47  | 0.05  | 0.76  | 0.15  | -0.04 | 0.17  |
| 22  | 1.59        | -4.42 | -3.39 | 2.43 | -0.51 | 1.53  | -0.47 | 0.75  | -0.01 | 0.25  | -0.11 |
| 23  | 1.35        | -4.74 | -2.86 | 1.94 | 0.32  | 1.09  | -0.39 | -0.15 | 0.35  | 0.16  | -0.02 |
| 24  | 1.29        | -5.45 | -2.64 | 1.53 | 0.82  | 0.51  | -0.19 | -0.69 | 0.59  | -0.05 | -0.01 |
| 25  | 1.22        | -5.75 | -2.44 | 1.33 | 1.60  | 0.12  | -0.33 | -0.77 | 0.11  | 0.08  | -0.01 |
| 26  | 1.01        | -5.65 | -2.66 | 0.96 | 1.73  | -0.23 | -0.30 | 0.02  | -0.46 | -0.09 | 0.31  |
| 27  | 0.77        | -5.24 | -2.85 | 0.76 | 1.71  | -0.59 | -0.08 | 0.94  | -0.43 | 0.43  | 0.24  |
| 28  | 0.77        | -4.91 | -3.38 | 0.71 | 1.64  | -0.59 | 0.85  | 1.37  | -0.16 | 0.45  | 0.23  |
| 29  | -0.35       | -4.60 | -3.27 | 1.05 | 1.52  | -0.14 | 2.45  | 1.11  | 0.29  | -0.25 | -0.15 |



Table C.1. cont'

|    |       |       |       |      |       |       |       |       |       |       |       |
|----|-------|-------|-------|------|-------|-------|-------|-------|-------|-------|-------|
| 30 | -1.22 | -3.90 | -3.04 | 1.52 | 1.12  | 0.21  | 3.10  | 0.20  | -0.06 | -0.38 | 0.31  |
| 31 | -2.16 | -3.35 | -2.61 | 2.31 | 0.78  | 0.69  | 1.91  | -0.71 | -0.04 | 0.04  | -0.04 |
| 32 | -2.63 | -2.64 | -2.68 | 2.73 | 0.34  | 1.00  | -0.26 | -0.69 | 0.09  | -0.03 | -0.09 |
| 33 | -2.25 | -2.29 | -1.80 | 1.98 | 0.31  | 1.33  | -1.77 | 0.01  | -0.44 | 0.12  | 0.36  |
| 34 | -2.46 | -2.96 | -1.77 | 2.02 | 1.21  | 0.16  | -1.95 | 0.79  | -0.50 | 0.40  | -0.22 |
| 35 | -1.85 | -2.07 | -1.65 | 2.10 | 1.61  | -0.67 | -0.61 | -0.17 | -0.19 | 0.01  | -0.36 |
| 36 | -2.20 | -1.93 | -2.11 | 2.39 | 1.63  | -1.05 | 0.10  | -0.90 | 0.52  | -0.08 | 0.07  |
| 37 | -2.04 | -2.03 | -1.70 | 2.99 | 1.60  | -1.10 | 0.45  | -0.85 | 0.44  | -0.10 | -0.01 |
| 38 | -2.84 | -2.36 | -2.44 | 3.33 | 2.01  | -0.77 | 1.03  | -0.65 | 0.05  | 0.05  | -0.27 |
| 39 | -3.52 | -3.23 | -1.50 | 4.01 | 0.66  | -0.90 | 2.00  | -0.76 | -0.34 | 0.29  | 0.01  |
| 40 | -4.11 | -3.89 | -1.36 | 4.57 | -0.05 | -0.39 | 1.52  | -0.88 | -0.11 | 0.17  | -0.01 |
| 41 | -4.42 | -4.38 | -1.47 | 4.59 | -0.0  | 0.79  | 0.75  | -0.08 | -0.18 | -0.02 | 0.06  |
| 42 | -5.00 | -4.11 | -1.37 | 4.25 | -0.76 | -0.10 | -1.26 | 0.40  | -0.98 | 0.64  | 0.31  |
| 43 | -5.07 | -4.08 | 0.55  | 3.30 | -0.75 | -1.42 | -0.19 | 0.46  | -0.66 | 0.41  | -0.55 |
| 44 | -5.20 | -3.37 | -0.91 | 3.32 | -0.14 | -1.59 | -0.15 | 0.40  | -0.29 | 0.14  | -0.32 |
| 45 | -5.32 | -3.20 | -0.39 | 3.30 | -0.04 | -1.55 | 0.51  | 0.89  | 0.09  | 0.14  | -0.33 |
| 46 | -5.14 | -3.54 | -0.42 | 3.32 | 0.07  | -1.22 | 0.33  | 0.71  | -0.02 | 0.29  | -0.23 |
| 47 | -5.00 | -3.59 | -0.28 | 3.05 | -0.16 | -0.81 | 0.50  | -0.32 | -0.39 | -0.22 | -0.17 |
| 48 | -5.17 | -3.73 | -0.16 | 3.01 | -0.65 | 0.04  | 0.35  | -1.02 | -0.43 | -0.60 | -0.10 |
| 49 | -5.31 | -2.88 | 0.26  | 3.04 | -0.99 | 0.72  | -0.13 | -0.65 | 0.02  | -0.14 | 0.13  |
| 50 | -5.86 | -2.83 | 0.35  | 2.85 | -1.74 | 1.37  | -0.97 | 0.12  | 0.16  | 0.56  | 0.16  |
| 51 | -5.81 | -2.09 | -0.70 | 2.56 | -1.55 | 1.42  | -0.19 | -0.36 | 0.34  | 0.43  | 0.28  |
| 52 | -5.27 | -2.91 | 0.30  | 2.27 | -1.63 | 1.51  | -1.17 | 1.16  | -0.78 | 0.05  | -0.67 |
| 53 | -5.61 | -5.03 | -0.25 | 2.09 | -0.47 | -0.21 | 0.38  | 0.92  | -1.68 | 0.67  | 0.56  |
| 54 | -4.72 | -2.67 | -0.44 | 1.96 | -0.79 | 0.46  | 0.14  | 0.71  | -1.23 | 0.29  | 0.43  |
| 55 | -4.73 | -2.12 | -1.43 | 1.73 | 0.03  | -0.15 | 0.54  | 0.42  | -0.70 | 0.20  | 0.60  |
| 56 | -4.61 | -2.44 | -1.69 | 2.03 | -0.10 | -0.11 | 1.02  | -0.45 | 0.18  | -0.22 | -0.40 |
| 57 | -5.31 | -2.10 | -2.18 | 2.51 | -0.03 | 0.11  | 1.00  | -0.12 | 1.01  | -1.07 | 0.01  |
| 58 | -5.60 | -2.18 | -2.98 | 2.64 | 0.14  | 0.74  | 0.62  | 0.29  | 0.62  | -0.98 | 0.53  |
| 59 | -5.45 | -1.89 | -2.86 | 2.82 | 0.51  | 0.67  | 0.39  | 0.33  | -0.26 | -0.20 | 0.41  |
| 60 | -5.16 | -1.58 | -3.38 | 2.67 | 0.57  | 0.43  | 0.33  | -0.32 | -0.62 | 0.36  | -0.15 |
| 61 | -4.96 | -0.93 | -3.94 | 2.91 | 0.59  | -0.15 | 0.16  | -0.74 | -0.36 | 0.38  | -0.42 |
| 62 | -4.58 | -0.42 | -4.37 | 2.67 | 0.73  | -0.28 | -0.25 | -0.54 | 0.39  | -0.04 | -0.27 |
| 63 | -4.37 | 0.10  | -4.57 | 2.36 | 0.75  | -0.30 | 0.04  | 0.23  | 0.65  | -0.48 | -0.04 |
| 64 | -4.07 | 0.30  | -5.27 | 2.91 | 0.93  | -0.32 | 0.53  | 0.58  | 0.38  | -0.68 | -0.10 |





Table C.1. cont'

|    |       |       |       |      |       |       |       |       |       |       |       |
|----|-------|-------|-------|------|-------|-------|-------|-------|-------|-------|-------|
| 65 | -2.95 | 0.30  | -5.68 | 3.34 | 0.77  | -0.87 | 1.00  | 0.49  | -0.49 | -0.45 | 0.41  |
| 66 | -3.52 | 0.19  | -6.33 | 3.57 | 0.71  | -1.04 | 1.37  | -0.10 | -0.55 | -0.01 | 0.36  |
| 67 | -3.06 | -0.22 | -5.91 | 3.25 | 0.0   | -1.70 | 0.77  | -0.82 | -0.04 | 0.88  | -0.37 |
| 68 | -3.35 | -0.72 | -6.07 | 2.81 | -1.01 | -1.74 | -0.20 | -0.72 | 0.23  | 0.18  | -0.24 |
| 69 | -3.81 | -1.58 | -5.84 | 2.75 | -1.36 | -1.64 | -0.55 | 0.24  | 0.39  | -0.50 | 0.28  |
| 70 | -3.29 | -2.64 | -5.69 | 2.46 | -1.08 | -1.48 | 0.01  | 1.05  | -0.10 | -0.40 | 0.39  |
| 71 | -3.27 | -3.56 | -4.92 | 2.20 | -0.55 | -1.15 | 1.48  | 0.90  | -0.45 | -0.08 | 0.20  |
| 72 | -3.25 | -4.29 | -4.47 | 1.92 | 0.09  | -0.96 | 2.16  | 0.53  | -0.52 | -0.03 | 0.13  |
| 73 | -3.24 | -4.75 | -3.42 | 1.92 | 0.66  | -0.37 | 1.68  | -0.0  | -0.09 | -0.28 | 0.41  |
| 74 | -3.18 | -5.85 | -2.59 | 1.31 | 0.91  | -0.06 | 1.07  | -0.15 | -0.04 | -0.41 | 0.43  |
| 75 | -2.99 | -6.03 | -1.86 | 0.72 | 0.65  | 0.29  | 0.36  | -0.13 | -0.27 | -0.35 | 0.09  |
| 76 | -2.82 | -6.49 | -1.80 | 0.34 | 0.47  | 0.80  | 0.08  | -0.12 | -0.50 | 0.31  | -0.23 |
| 77 | -3.18 | -6.40 | -1.68 | 0.40 | -0.34 | 1.10  | -0.29 | 0.04  | -0.22 | 0.66  | -0.11 |
| 78 | -3.10 | -6.37 | -2.06 | 0.30 | -0.73 | 1.88  | -0.78 | 0.10  | 0.23  | 0.17  | 0.21  |
| 79 | -4.30 | -5.54 | -2.05 | 0.58 | -0.05 | 2.04  | -0.49 | 0.44  | -0.25 | 0.48  | 0.12  |
| 80 | -4.42 | -5.35 | -2.40 | 0.24 | 0.12  | 2.10  | -0.60 | 0.16  | -0.20 | 0.14  | 0.22  |
| 81 | -5.37 | -4.64 | -2.46 | 0.76 | 0.30  | 2.94  | -0.63 | 0.85  | -0.25 | 0.31  | 0.27  |
| 82 | -5.73 | -4.30 | -2.71 | 0.16 | 0.98  | 2.32  | -0.38 | 0.22  | -0.57 | 0.10  | 0.24  |
| 83 | -6.56 | -4.10 | -2.51 | 0.50 | 1.51  | 1.68  | -0.52 | -0.36 | -0.47 | 0.36  | 0.02  |
| 84 | -7.35 | -4.20 | -2.14 | 0.54 | 1.92  | 1.12  | -0.05 | -0.66 | 0.29  | 0.49  | 0.36  |
| 85 | -7.00 | -3.95 | -2.82 | 0.87 | 1.04  | 1.16  | -0.62 | -0.35 | -0.33 | -0.17 | 0.15  |
| 86 | -7.40 | -3.80 | -3.21 | 1.26 | 1.11  | 0.80  | -0.47 | -0.14 | -0.13 | -0.03 | 0.53  |
| 87 | -7.49 | -3.83 | -3.05 | 1.19 | 0.55  | 0.62  | -0.76 | -0.30 | -0.21 | -0.73 | 0.22  |
| 88 | -7.42 | -3.38 | -4.29 | 1.92 | 0.18  | 0.43  | -0.89 | 0.31  | -0.52 | -0.51 | 0.67  |
| 89 | -7.09 | -2.96 | -5.09 | 2.67 | 0.38  | 0.11  | -0.69 | 0.34  | -0.45 | 0.15  | 0.63  |
| 90 | -6.82 | -2.38 | -6.06 | 3.14 | 0.52  | -0.27 | -0.44 | -0.32 | -0.11 | 0.60  | -0.12 |
| 91 | -6.96 | -1.12 | -6.40 | 2.58 | 1.22  | -0.30 | 0.24  | -0.59 | 0.29  | 0.06  | 0.08  |
| 92 | -6.65 | -1.12 | -6.20 | 2.96 | 1.95  | -0.24 | -0.99 | -1.05 | 0.18  | 0.05  | -0.42 |
| 93 | -5.75 | -0.79 | -6.21 | 3.29 | 2.11  | 0.41  | -1.09 | -0.53 | -0.04 | -0.0  | -0.32 |
| 94 | -4.96 | -0.39 | -6.40 | 3.43 | 1.88  | 1.07  | -0.81 | -0.13 | -0.36 | -0.01 | 0.15  |
| 95 | -4.39 | -0.97 | -5.97 | 3.84 | 2.31  | 1.39  | -0.42 | 0.99  | -0.75 | -0.07 | 0.25  |
| 96 | -4.06 | -1.09 | -6.03 | 3.21 | 1.86  | 1.52  | -0.21 | 0.81  | -0.99 | 0.44  | -0.01 |
| 97 | -4.27 | -1.90 | -4.93 | 2.79 | 1.14  | 2.14  | -0.42 | 0.33  | -0.38 | 0.17  | -0.47 |
| 98 | -3.58 | -2.44 | -5.20 | 2.48 | 1.07  | 1.82  | -0.31 | 0.16  | -0.32 | -0.24 | 0.09  |
| 99 | -3.77 | -2.97 | -4.60 | 2.16 | 0.42  | 1.98  | -0.01 | -0.06 | 0.10  | -0.55 | 0.09  |



Table C.1. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 100 | -3.67 | -4.33 | -3.80 | 1.47  | -0.07 | 1.83  | -0.05 | -0.51 | 0.35  | -0.18 | -0.01 |
| 101 | -3.66 | -4.37 | -3.58 | 0.22  | -0.41 | 1.53  | 0.31  | -0.92 | 0.46  | 0.08  | -0.14 |
| 102 | -3.04 | -3.80 | -2.39 | 1.06  | -0.70 | 1.33  | -1.03 | -0.74 | 0.45  | 0.36  | 0.06  |
| 103 | -3.09 | -3.72 | -1.50 | 1.40  | -0.30 | 0.68  | -1.23 | -0.32 | -0.06 | 0.08  | -0.06 |
| 104 | -3.53 | -3.57 | -1.12 | 2.03  | 0.46  | 0.90  | -1.03 | 0.06  | -0.44 | 0.02  | -0.08 |
| 105 | -4.11 | -3.03 | -0.94 | 2.35  | 1.11  | 0.84  | 0.04  | 0.67  | -0.15 | 0.31  | -0.11 |
| 106 | -4.09 | -2.74 | -1.33 | 2.32  | 1.29  | 0.79  | 0.63  | 0.66  | -0.20 | 0.12  | 0.09  |
| 107 | -4.31 | -2.23 | -1.18 | 2.21  | 1.19  | 0.30  | 0.68  | 0.01  | 0.01  | -0.0  | 0.19  |
| 108 | -4.22 | -2.29 | -1.40 | 2.05  | 0.95  | -0.06 | 0.26  | -0.57 | 0.61  | 0.19  | 0.10  |
| 109 | -4.67 | -2.43 | -0.96 | 2.55  | 0.73  | -0.26 | 0.09  | -0.65 | 0.95  | 0.19  | -0.24 |
| 110 | -4.72 | -2.88 | -1.46 | 2.76  | 0.41  | -0.34 | -0.0  | -0.85 | 0.96  | -0.01 | -0.31 |
| 111 | -4.61 | -3.01 | -1.92 | 2.72  | 0.05  | 0.02  | 0.19  | -0.92 | 0.26  | 0.14  | -0.07 |
| 112 | -3.73 | -2.81 | -2.54 | 2.13  | -0.27 | 0.59  | -0.27 | -1.02 | -0.47 | 0.15  | -0.04 |
| 113 | -3.20 | -2.08 | -4.09 | 1.61  | 0.35  | 0.55  | 0.21  | -0.58 | -0.05 | 0.36  | 0.04  |
| 114 | -2.76 | -1.94 | -4.04 | 1.51  | 0.32  | 0.21  | 0.09  | -0.43 | 0.27  | -0.04 | 0.07  |
| 115 | -3.04 | -1.35 | -3.34 | 1.92  | 0.23  | 0.07  | 0.08  | 0.14  | 0.40  | -0.50 | -0.16 |
| 116 | -3.08 | -2.21 | -2.89 | 2.28  | -0.43 | 0.71  | -0.54 | 0.39  | -0.07 | 0.16  | 0.09  |
| 117 | -2.96 | -1.97 | -2.19 | 2.14  | -0.79 | 0.70  | -0.61 | 0.58  | -0.95 | 0.62  | 0.19  |
| 118 | -2.98 | -2.66 | -1.48 | 1.33  | -0.51 | 0.36  | -0.61 | 0.15  | -1.03 | 0.96  | 0.02  |
| 119 | -3.37 | -3.02 | -0.81 | 0.84  | 0.09  | 0.31  | -0.08 | 0.20  | -0.54 | 0.31  | -0.38 |
| 120 | -2.74 | -3.86 | -0.51 | 0.66  | 0.79  | 1.05  | -0.02 | 0.12  | 0.36  | -0.27 | 0.20  |
| 121 | -2.78 | -4.16 | -0.86 | 0.58  | 1.00  | 1.17  | -1.12 | 0.44  | 0.21  | -0.11 | 0.10  |
| 122 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 123 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 124 | -3.16 | -4.38 | -2.31 | 0.36  | 1.94  | -0.51 | -0.85 | -0.85 | -0.06 | 0.06  | 0.27  |
| 125 | -2.94 | -4.07 | -2.67 | 0.63  | 2.33  | -0.78 | -0.14 | -0.75 | -0.05 | 0.30  | 0.24  |
| 126 | -2.72 | -3.99 | -3.22 | 0.52  | 2.55  | -1.04 | 0.45  | -0.50 | 0.15  | 0.65  | 0.03  |
| 127 | -2.49 | -3.28 | -3.59 | 1.00  | 2.16  | -0.87 | 0.64  | -0.47 | 0.09  | 0.16  | 0.14  |
| 128 | -2.24 | -2.55 | -3.94 | 1.48  | 1.67  | -0.74 | 0.86  | -0.43 | 0.01  | -0.35 | 0.30  |
| 129 | -2.15 | -2.17 | -3.73 | 2.32  | 1.23  | -0.59 | 0.43  | -0.42 | 0.15  | -0.47 | 0.55  |
| 130 | -2.26 | -2.22 | -3.77 | 2.74  | 0.44  | -0.24 | -0.21 | -0.40 | -0.16 | -0.25 | 0.40  |
| 131 | -2.52 | -2.34 | -3.40 | 3.17  | -0.06 | -0.34 | -0.54 | -0.45 | -0.46 | 0.29  | 0.15  |
| 132 | -2.74 | -2.81 | -3.58 | 2.73  | -0.62 | -0.77 | -0.75 | -0.09 | 0.01  | 0.47  | 0.51  |
| 133 | -3.07 | -3.16 | -3.72 | 2.60  | -1.08 | -0.70 | -0.65 | 0.22  | 0.06  | 0.72  | 0.18  |
| 134 | -3.17 | -3.42 | -3.71 | 2.58  | -1.23 | -0.52 | -0.24 | 0.18  | 0.47  | 0.34  | -0.33 |



Table C.1. cont'

|     |       |       |       |      |       |       |       |       |       |       |       |
|-----|-------|-------|-------|------|-------|-------|-------|-------|-------|-------|-------|
| 135 | -3.29 | -3.47 | -3.28 | 2.87 | -1.27 | -0.0  | -0.17 | 0.35  | 0.37  | 0.06  | -0.14 |
| 136 | -3.30 | -3.62 | -2.87 | 3.08 | -1.32 | 0.53  | -0.10 | 0.48  | 0.24  | -0.19 | 0.04  |
| 137 | -3.30 | -3.33 | -2.24 | 3.62 | -1.35 | 0.97  | -0.32 | 0.38  | -0.31 | -0.01 | 0.09  |
| 138 | -3.16 | -3.42 | -2.31 | 3.77 | -1.13 | 1.31  | -0.48 | 0.03  | -0.60 | 0.17  | 0.03  |
| 139 | -2.83 | -3.85 | -2.06 | 3.46 | -0.98 | 0.99  | -0.83 | -0.53 | -0.16 | 0.57  | 0.28  |
| 140 | -2.31 | -4.09 | -1.86 | 2.79 | -0.80 | 0.58  | -1.16 | -0.85 | 0.46  | 0.37  | -0.02 |
| 141 | -2.31 | -4.09 | -1.86 | 2.79 | -0.80 | 0.58  | -1.16 | -0.85 | 0.46  | 0.37  | -0.02 |
| 142 | -2.51 | -4.67 | -1.06 | 2.04 | -0.20 | -0.03 | -1.16 | -0.57 | 0.04  | -0.38 | 0.05  |
| 143 | -2.73 | -4.54 | -0.65 | 1.33 | -0.23 | -0.78 | -0.65 | -0.18 | -0.71 | 0.13  | 0.11  |
| 144 | -2.65 | -4.75 | -0.46 | 1.18 | -0.02 | -1.04 | 0.07  | 0.25  | -0.70 | 0.62  | -0.15 |
| 145 | -2.94 | -4.60 | -0.36 | 1.56 | 0.34  | -1.40 | 1.00  | 0.20  | -0.17 | 0.08  | -0.10 |
| 146 | -3.31 | -4.58 | -0.41 | 1.55 | 0.48  | -1.46 | 1.07  | 0.14  | -0.22 | 0.13  | -0.05 |
| 147 | -3.79 | -4.48 | -0.54 | 1.59 | 0.71  | -1.52 | 1.07  | 0.20  | -0.25 | 0.04  | 0.05  |
| 148 | -4.51 | -4.25 | -1.77 | 1.59 | 0.11  | -1.21 | 0.21  | 0.03  | -0.63 | 0.60  | -0.16 |
| 149 | -5.03 | -4.06 | -1.96 | 1.11 | -0.45 | -1.36 | -0.13 | -0.29 | 0.12  | 0.11  | 0.04  |
| 150 | -4.68 | -3.74 | -2.93 | 0.25 | -1.06 | -1.26 | -0.37 | 0.14  | 0.81  | 0.15  | 0.43  |
| 151 | -4.90 | -3.85 | -3.00 | 0.05 | -0.93 | -0.28 | 0.20  | 0.81  | 0.12  | 0.17  | -0.57 |
| 152 | -4.77 | -4.21 | -2.95 | 0.08 | -0.48 | 0.54  | 0.41  | 0.69  | -0.79 | 0.15  | -0.46 |
| 153 | -4.54 | -3.99 | -2.49 | 0.30 | -0.14 | 0.73  | 0.66  | 0.0   | -0.83 | -0.17 | 0.24  |
| 154 | -4.25 | -3.83 | -2.08 | 0.54 | 0.23  | 0.06  | 0.71  | -0.18 | -0.72 | -0.53 | 0.27  |
| 155 | -3.57 | -4.19 | -2.16 | 1.38 | 0.63  | 0.02  | 0.77  | -0.26 | -0.29 | -0.14 | -0.15 |
| 156 | -4.18 | -4.40 | -1.71 | 1.43 | 1.37  | -0.34 | 1.14  | -0.34 | 0.04  | 0.06  | -0.07 |
| 157 | -4.08 | -4.46 | -1.44 | 1.46 | 1.63  | -0.08 | 1.01  | -0.06 | 0.40  | -0.04 | -0.20 |
| 158 | -3.68 | -4.56 | -1.56 | 1.29 | 1.56  | 0.21  | 0.23  | -0.12 | 0.33  | -0.23 | 0.07  |
| 159 | -3.67 | -4.59 | -1.56 | 1.48 | 1.19  | 0.20  | -1.00 | -0.41 | 0.31  | -0.16 | 0.16  |
| 160 | -3.05 | -5.12 | -1.76 | 1.49 | 1.05  | 0.28  | -1.47 | -0.08 | 0.43  | 0.03  | -0.07 |
| 161 | -3.21 | -5.13 | -1.50 | 1.85 | 0.81  | 0.58  | -1.20 | 0.36  | 0.20  | -0.13 | -0.32 |
| 162 | -2.79 | -5.24 | -1.57 | 1.69 | 1.11  | 0.74  | -1.03 | 0.49  | -0.22 | -0.49 | 0.18  |
| 163 | -2.86 | -4.82 | -1.57 | 2.02 | 1.36  | 0.82  | -0.72 | 0.37  | -0.60 | -0.40 | 0.02  |
| 164 | -2.90 | -5.01 | -1.88 | 2.13 | 1.77  | 0.75  | -0.39 | 0.04  | -0.22 | 0.19  | -0.21 |
| 165 | -3.21 | -4.57 | -1.86 | 2.31 | 1.70  | 0.83  | 0.39  | -0.23 | 0.16  | 0.35  | -0.33 |
| 166 | -3.80 | -4.63 | -1.77 | 2.28 | 1.09  | 0.54  | 0.83  | -0.17 | 0.55  | 0.14  | -0.21 |
| 167 | -3.87 | -4.63 | -1.57 | 2.15 | 0.52  | 0.20  | 0.95  | -0.04 | 0.26  | 0.15  | 0.22  |
| 168 | -4.30 | -4.90 | -1.74 | 1.64 | -0.73 | -0.25 | 0.94  | -0.14 | -0.14 | 0.32  | 0.36  |
| 169 | -4.10 | -4.93 | -1.49 | 1.76 | -0.90 | -0.97 | 0.86  | 0.16  | 0.19  | 0.25  | 0.32  |





Table C.1. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 170 | -4.03 | -5.31 | -1.47 | 1.96  | -1.33 | -1.40 | 1.19  | 0.02  | 0.24  | 0.11  | 0.14  |
| 171 | -3.84 | -5.77 | -1.54 | 1.94  | -1.47 | -1.72 | 1.05  | -0.25 | 0.17  | -0.10 | -0.06 |
| 172 | -3.93 | -6.06 | -1.55 | 2.47  | -1.20 | -1.72 | 0.61  | -0.31 | 0.01  | -0.05 | 0.11  |
| 173 | -3.91 | -6.10 | -0.97 | 3.50  | -0.92 | -1.68 | -0.65 | -0.21 | -0.08 | 0.34  | 0.20  |
| 174 | -4.21 | -6.42 | -0.77 | 4.04  | -0.30 | -1.48 | -1.11 | 0.11  | -0.17 | 0.47  | -0.20 |
| 175 | -4.35 | -6.35 | -0.41 | 4.39  | 0.18  | -1.28 | -0.74 | 0.41  | -0.24 | -0.05 | -0.02 |
| 176 | -4.46 | -6.24 | -0.25 | 4.69  | 0.65  | -1.42 | -0.02 | 0.52  | 0.30  | -0.53 | 0.45  |
| 177 | -4.40 | -6.03 | -0.19 | 4.52  | 0.76  | -1.29 | 0.96  | 0.75  | 0.22  | -0.60 | 0.13  |
| 178 | -4.63 | -5.41 | -0.55 | 4.11  | 0.59  | -1.03 | 1.14  | 0.67  | 0.08  | -0.27 | -0.48 |
| 179 | -4.88 | -4.69 | -0.98 | 3.57  | 0.07  | -0.47 | 1.55  | 0.16  | 0.10  | -0.05 | -0.41 |
| 180 | -5.21 | -4.20 | -1.92 | 3.11  | -0.68 | -0.05 | 0.96  | -0.48 | 0.11  | 0.03  | -0.21 |
| 181 | -5.79 | -3.94 | -2.67 | 2.41  | -1.52 | 0.42  | 0.28  | -0.75 | -0.14 | 0.07  | -0.13 |
| 182 | -6.26 | -3.76 | -3.31 | 1.72  | -2.32 | 0.78  | -0.71 | 0.19  | 0.01  | 0.68  | -0.06 |
| 183 | -6.76 | -3.58 | -3.10 | 0.87  | -2.15 | 1.03  | -0.82 | 1.34  | 0.02  | 0.36  | -0.17 |
| 184 | -5.95 | -3.96 | -2.55 | -0.34 | -1.53 | 0.92  | -0.94 | 1.56  | -0.32 | -0.20 | -0.27 |
| 185 | -6.02 | -3.58 | -1.53 | -0.80 | -0.28 | 1.21  | -0.71 | 1.14  | -0.92 | -0.13 | 0.29  |
| 186 | -5.70 | -3.62 | -1.01 | -0.86 | 0.58  | 0.64  | 0.24  | 0.02  | -0.13 | 0.29  | -0.39 |
| 187 | -5.14 | -2.58 | -0.86 | -1.10 | 1.04  | 0.80  | 0.09  | 0.17  | 0.07  | 0.24  | -0.50 |
| 188 | -5.04 | -2.43 | -1.30 | -1.22 | 1.23  | 0.41  | 0.65  | -0.65 | 0.66  | 0.15  | -0.29 |
| 189 | -5.12 | -2.32 | -1.05 | -0.79 | 1.38  | 0.07  | 0.49  | -1.15 | 0.72  | -0.30 | 0.18  |
| 190 | -4.86 | -2.40 | -0.90 | -0.69 | 1.01  | -0.90 | 0.28  | -0.90 | 0.46  | -0.13 | 0.19  |
| 191 | -5.09 | -2.59 | -0.52 | -0.38 | 0.80  | -1.80 | 0.45  | 0.16  | -0.02 | 0.20  | 0.10  |
| 192 | -4.97 | -2.36 | -1.34 | -0.64 | 0.88  | -2.61 | 0.71  | 0.74  | -0.10 | 0.23  | -0.21 |
| 193 | -5.13 | -1.81 | -1.93 | -0.18 | 1.14  | -2.99 | 1.32  | 0.64  | -0.26 | -0.01 | -0.33 |
| 194 | -4.40 | -1.59 | -3.32 | -0.01 | 1.39  | -2.75 | 1.99  | -0.33 | -0.16 | 0.05  | -0.07 |
| 195 | -4.13 | -1.83 | -3.87 | 0.68  | 1.89  | -2.02 | 2.06  | -1.05 | 0.09  | 0.10  | 0.21  |
| 196 | -3.47 | -1.66 | -4.59 | 1.04  | 2.07  | -1.16 | 1.84  | -1.27 | 0.73  | 0.05  | 0.16  |
| 197 | -3.61 | -1.20 | -4.38 | 1.63  | 1.90  | -0.21 | 1.15  | -1.16 | 0.58  | 0.23  | 0.37  |
| 198 | -2.94 | -1.41 | -3.92 | 1.33  | 2.20  | 0.26  | 0.85  | -0.71 | 0.41  | 0.13  | 0.02  |
| 199 | -2.79 | -1.49 | -3.46 | 0.85  | 2.48  | 0.65  | 0.42  | 0.28  | -0.09 | -0.08 | -0.20 |
| 200 | -3.12 | -1.62 | -3.54 | 0.21  | 2.67  | 0.32  | -0.35 | 0.57  | 0.15  | -0.33 | 0.14  |
| 201 | -3.51 | -1.90 | -3.18 | -0.50 | 2.35  | -0.14 | -1.38 | 0.96  | -0.13 | 0.03  | 0.02  |
| 202 | -3.99 | -1.89 | -3.43 | -1.44 | 1.61  | -0.79 | -1.61 | 1.09  | 0.48  | 0.46  | -0.24 |
| 203 | -4.09 | -1.59 | -3.23 | -1.92 | 1.00  | -1.42 | -0.50 | 0.63  | 0.16  | 0.53  | -0.69 |
| 204 | -4.12 | -1.41 | -2.84 | -2.11 | 0.61  | -1.69 | 0.53  | 0.72  | -0.13 | 0.16  | -0.67 |





Table C.1. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 205 | -3.60 | -1.34 | -1.68 | -2.11 | 0.35  | -2.27 | 0.62  | 0.60  | 0.28  | -0.18 | 0.06  |
| 206 | -3.02 | -1.36 | -1.38 | -2.41 | 1.05  | -1.91 | 0.68  | 0.64  | 0.25  | -0.36 | 0.22  |
| 207 | -3.10 | -1.55 | -0.62 | -2.27 | 1.99  | -1.34 | 0.45  | 0.36  | -0.38 | -0.20 | 0.29  |
| 208 | -2.78 | -2.07 | -0.16 | -2.43 | 2.48  | -0.75 | 0.76  | 0.13  | -0.34 | -0.21 | -0.10 |
| 209 | -2.67 | -1.77 | 0.26  | -2.45 | 2.43  | 0.12  | 1.54  | -0.07 | 0.28  | -0.42 | 0.23  |
| 210 | -2.98 | -1.41 | 0.25  | -2.28 | 2.06  | 0.85  | 1.18  | 0.11  | 0.85  | -0.15 | 0.14  |
| 211 | -3.02 | -1.39 | 0.78  | -2.72 | 1.49  | 0.95  | 1.22  | -0.01 | 0.42  | 0.37  | -0.04 |
| 212 | -2.95 | -1.41 | 0.67  | -2.89 | 1.19  | 0.42  | 0.85  | -0.50 | -0.77 | 0.28  | 0.46  |
| 213 | -3.18 | -1.66 | 0.60  | -2.23 | 0.56  | -0.47 | -0.31 | -0.89 | -0.95 | -0.10 | 0.58  |
| 214 | -2.74 | -2.31 | 0.42  | -2.09 | -0.09 | -1.35 | -1.30 | -0.88 | 0.10  | 0.23  | -0.15 |
| 215 | -2.54 | -2.96 | 0.82  | -2.42 | -1.21 | -1.80 | -1.23 | 0.18  | 0.58  | -0.05 | -0.13 |
| 216 | -2.54 | -3.37 | 0.76  | -2.58 | -1.74 | -1.72 | -1.03 | 1.37  | 0.34  | -0.42 | 0.27  |
| 217 | -2.24 | -3.86 | 0.94  | -2.77 | -1.51 | -0.78 | -0.62 | 1.52  | -0.33 | -0.46 | 0.12  |
| 218 | -1.99 | -4.25 | 0.69  | -2.97 | -0.81 | 0.16  | 0.00  | 0.47  | -0.64 | -0.35 | 0.08  |
| 219 | -1.87 | -4.08 | 0.67  | -2.75 | -0.07 | 0.82  | 0.31  | -0.36 | -0.75 | -0.48 | 0.59  |
| 220 | -1.85 | -4.15 | 0.48  | -2.57 | 0.46  | 0.90  | 0.51  | -0.39 | -0.48 | 0.34  | 0.16  |
| 221 | -2.03 | -3.58 | 0.54  | -2.51 | 0.49  | 0.75  | 0.55  | 0.09  | -0.14 | 0.58  | -0.50 |
| 222 | -2.40 | -3.41 | 0.14  | -2.83 | 0.67  | 0.42  | 0.78  | -0.13 | 0.42  | 0.15  | -0.39 |
| 223 | -3.28 | -3.35 | 0.24  | -2.58 | 1.37  | 0.54  | 1.27  | -0.54 | 0.17  | -0.34 | 0.26  |
| 224 | -3.62 | -3.53 | -0.02 | -2.16 | 1.75  | 0.03  | 1.59  | -0.81 | -0.14 | -0.43 | 0.29  |
| 225 | -3.50 | -3.32 | 0.09  | -1.43 | 1.73  | -0.14 | 1.45  | -0.39 | -0.40 | 0.00  | 0.36  |
| 226 | -3.24 | -2.93 | -0.65 | -0.68 | 1.10  | -0.22 | 1.02  | -0.15 | -0.67 | 0.52  | 0.27  |
| 227 | -2.92 | -2.68 | -1.29 | -0.33 | 0.91  | 0.53  | 0.52  | -0.00 | -0.59 | 0.60  | 0.18  |
| 228 | -2.70 | -2.46 | -2.10 | 0.14  | 0.53  | 1.10  | -0.29 | 0.05  | -0.47 | 0.10  | -0.15 |
| 229 | -2.52 | -2.07 | -2.55 | 0.71  | 0.16  | 1.35  | -0.69 | 0.71  | -0.61 | 0.10  | 0.10  |
| 230 | -2.46 | -1.56 | -3.18 | 1.04  | -0.16 | 1.51  | -0.46 | 1.16  | -0.89 | 0.14  | 0.21  |
| 231 | -2.63 | -1.28 | -3.02 | 1.73  | -0.41 | 1.54  | -0.46 | 0.92  | -0.56 | -0.06 | 0.02  |
| 232 | -2.63 | -1.18 | -3.40 | 2.51  | -0.66 | 1.46  | -0.91 | 1.11  | 0.13  | -0.37 | 0.23  |
| 233 | -2.78 | -1.19 | -3.25 | 2.87  | -0.69 | 0.95  | -1.27 | 1.16  | 0.09  | -0.33 | 0.51  |
| 234 | -2.85 | -0.90 | -3.38 | 2.91  | -0.55 | 0.48  | -1.74 | 0.98  | 0.03  | 0.26  | 0.21  |
| 235 | -2.93 | -0.70 | -3.02 | 2.78  | -0.38 | -0.33 | -2.10 | 0.80  | -0.04 | 0.32  | -0.33 |
| 236 | -2.41 | -0.80 | -2.94 | 2.18  | -0.26 | -0.33 | -2.00 | 0.58  | -0.05 | 0.10  | -0.23 |
| 237 | -2.00 | -0.94 | -2.60 | 1.60  | -0.13 | -0.21 | -1.71 | 0.49  | -0.38 | 0.06  | -0.04 |
| 238 | -1.75 | -0.87 | -2.51 | 0.71  | 0.09  | 0.05  | -0.71 | 0.46  | -0.69 | 0.31  | -0.16 |
| 239 | -2.19 | -0.95 | -2.00 | 0.07  | 0.37  | 0.46  | 0.56  | 0.57  | -0.54 | 0.12  | -0.27 |
| 240 | -2.24 | -0.91 | -1.56 | -0.49 | 0.98  | 1.04  | 1.51  | 0.62  | 0.02  | -0.07 | 0.04  |



Table C.2. Values of BAMPL for NUMB = 240

| Row | Wave Number |      |       |       |       |       |       |       |       |       |       |
|-----|-------------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|     | 1           | 2    | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    |
| 1   | -0.36       | 1.48 | -0.86 | 3.74  | 0.25  | 1.55  | 0.60  | 0.10  | 0.51  | -0.23 | -0.01 |
| 2   | -1.32       | 1.56 | -0.68 | 3.77  | 0.14  | 1.57  | 0.63  | -0.26 | -0.06 | -0.33 | 0.11  |
| 3   | -1.27       | 1.56 | -0.69 | 3.29  | -0.01 | 1.60  | 0.85  | -0.74 | -0.27 | -0.34 | 0.02  |
| 4   | -1.88       | 1.62 | -0.68 | 2.30  | -0.20 | 1.23  | 1.22  | -1.19 | -0.33 | -0.11 | -0.03 |
| 5   | -1.45       | 1.77 | -0.71 | 1.72  | 0.48  | 1.81  | 1.27  | -1.35 | -0.16 | -0.08 | 0.11  |
| 6   | -1.67       | 1.12 | -0.91 | 1.35  | 0.93  | 2.21  | 1.08  | -0.88 | -0.19 | -0.04 | 0.09  |
| 7   | -1.04       | 0.93 | -1.17 | 1.13  | 1.33  | 3.19  | 0.82  | -0.03 | -0.86 | 0.51  | -0.26 |
| 8   | -1.01       | 1.12 | -1.11 | 0.83  | 1.96  | 3.22  | 0.81  | 0.36  | -0.42 | 0.26  | -0.18 |
| 9   | -0.53       | 1.40 | -1.41 | 0.13  | 2.78  | 2.87  | 0.90  | 0.10  | 0.23  | -0.18 | -0.21 |
| 10  | -0.76       | 1.94 | -1.60 | -0.58 | 3.82  | 2.52  | 0.43  | 0.09  | 0.16  | -0.13 | -0.63 |
| 11  | -0.18       | 2.60 | -1.89 | -1.00 | 4.48  | 2.47  | -0.29 | 0.45  | 0.21  | 0.09  | -0.08 |
| 12  | -0.48       | 2.97 | -1.90 | -1.53 | 4.30  | 2.10  | -0.60 | 0.54  | 0.32  | 0.14  | 0.29  |
| 13  | -0.29       | 3.19 | -2.26 | -2.08 | 3.87  | 1.17  | -0.60 | -0.03 | -0.28 | 0.11  | 0.20  |
| 14  | -0.24       | 3.24 | -2.68 | -2.61 | 3.18  | 0.67  | -1.04 | -0.40 | -0.52 | -0.21 | 0.32  |
| 15  | 0.53        | 2.61 | -2.75 | -2.67 | 2.09  | -0.02 | -1.75 | -0.35 | -0.49 | -0.04 | 0.19  |
| 16  | 0.91        | 1.31 | -2.07 | -2.59 | 1.33  | -0.53 | -1.81 | -0.14 | 0.10  | -0.06 | -0.02 |
| 17  | 1.70        | 0.42 | -0.93 | -2.47 | 0.94  | -0.56 | -1.26 | 0.15  | -0.06 | 0.02  | 0.08  |
| 18  | 1.63        | 0.12 | -0.44 | -2.76 | 0.24  | -0.49 | -0.77 | 0.02  | -0.49 | 0.28  | 0.40  |
| 19  | 1.74        | 0.24 | -0.12 | -2.84 | 0.24  | -0.24 | -0.19 | -0.11 | -0.28 | 0.54  | 0.09  |
| 20  | 1.22        | 0.39 | 0.51  | -3.11 | 0.08  | -0.45 | 0.64  | -0.34 | 0.16  | 0.20  | -0.09 |
| 21  | 0.71        | 1.01 | 0.42  | -2.90 | -0.57 | 0.01  | 0.69  | -0.0  | 0.36  | -0.06 | 0.06  |
| 22  | 0.18        | 1.50 | 0.64  | -2.93 | -1.32 | 0.83  | 0.26  | 0.65  | 0.26  | -0.05 | 0.25  |
| 23  | -0.01       | 1.72 | 1.13  | -2.78 | -1.49 | 1.60  | -0.24 | 0.98  | -0.20 | 0.28  | 0.07  |
| 24  | -1.01       | 1.82 | 1.32  | -2.89 | -1.44 | 1.55  | -0.33 | 0.43  | 0.45  | 0.26  | 0.16  |
| 25  | -1.19       | 1.84 | 1.59  | -2.67 | -0.76 | 1.23  | -0.55 | -0.43 | 0.65  | 0.30  | 0.04  |
| 26  | -1.78       | 1.62 | 1.62  | -2.20 | -0.04 | 0.63  | -0.79 | -1.12 | 0.55  | 0.03  | -0.16 |
| 27  | -1.93       | 1.98 | 1.63  | -1.80 | 0.50  | 0.13  | -1.46 | -1.10 | -0.11 | -0.21 | 0.19  |
| 28  | -2.23       | 2.61 | 2.03  | -1.31 | 1.26  | -0.32 | -1.92 | -0.42 | -0.45 | 0.21  | 0.02  |
| 29  | -2.38       | 3.10 | 1.77  | -1.17 | 1.60  | -0.80 | -1.29 | 0.50  | -0.02 | 0.35  | 0.01  |



Table C.2. cont'

|    |       |      |       |       |       |       |       |       |       |       |       |
|----|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 30 | -2.35 | 3.55 | 1.51  | -0.86 | 2.12  | -0.89 | 0.64  | 0.50  | 0.24  | -0.20 | 0.15  |
| 31 | -2.30 | 3.89 | 1.40  | -0.22 | 2.22  | -1.07 | 2.26  | 0.13  | 0.09  | -0.16 | 0.07  |
| 32 | -2.71 | 3.93 | 0.27  | 0.79  | 1.43  | -0.56 | 2.73  | -0.98 | 0.26  | 0.04  | -0.13 |
| 33 | -1.61 | 3.63 | -0.84 | 1.14  | 0.67  | 0.63  | 1.08  | -1.53 | 0.69  | -0.13 | -0.12 |
| 34 | -2.16 | 2.95 | -1.17 | 1.60  | -0.45 | 1.43  | -0.53 | -0.28 | -0.09 | -0.10 | 0.15  |
| 35 | -2.26 | 2.53 | -1.66 | 1.36  | -0.54 | 1.49  | -1.10 | 0.28  | -0.61 | -0.03 | -0.15 |
| 36 | -2.91 | 2.52 | -2.28 | 1.21  | -0.59 | 1.21  | -0.59 | -0.12 | -0.17 | -0.23 | -0.23 |
| 37 | -3.12 | 2.05 | -2.35 | 1.31  | -0.40 | 1.43  | -0.75 | -0.50 | 0.79  | -0.61 | 0.17  |
| 38 | -3.67 | 2.14 | -2.00 | 0.38  | -0.34 | 1.31  | -0.75 | -0.72 | 1.02  | -0.19 | 0.20  |
| 39 | -3.65 | 2.20 | -1.84 | 0.92  | 0.48  | 0.93  | 0.06  | -0.16 | 0.59  | -0.14 | -0.09 |
| 40 | -4.02 | 2.55 | -1.68 | 1.12  | 0.40  | 0.86  | 1.15  | -0.60 | 0.32  | 0.18  | 0.07  |
| 41 | -3.30 | 3.74 | -1.57 | 0.49  | -1.36 | 0.15  | 1.37  | -1.03 | 1.20  | 0.06  | 0.02  |
| 42 | -4.23 | 3.32 | -1.86 | 1.25  | -0.88 | 1.17  | 0.68  | -0.95 | 0.58  | -0.57 | -0.0  |
| 43 | -3.98 | 2.39 | -2.07 | 2.30  | -0.80 | 0.79  | -0.94 | -0.16 | -0.27 | 0.91  | -0.39 |
| 44 | -3.49 | 2.95 | -1.96 | 0.38  | -0.36 | 0.54  | -0.74 | -1.03 | -0.29 | 0.44  | -0.14 |
| 45 | -2.73 | 2.73 | -0.99 | -0.38 | -0.15 | -0.23 | -0.18 | -0.52 | -0.19 | 0.03  | -0.10 |
| 46 | -2.90 | 2.42 | -0.53 | -0.37 | 0.26  | -0.68 | 0.04  | 0.40  | -0.02 | 0.10  | -0.20 |
| 47 | -2.68 | 2.36 | -0.15 | -0.09 | 1.08  | -1.09 | 0.46  | 0.73  | 0.14  | 0.40  | -0.10 |
| 48 | -3.18 | 2.82 | 0.15  | 0.11  | 1.36  | -1.27 | 1.00  | -0.02 | -0.42 | 0.0   | -0.12 |
| 49 | -2.10 | 3.32 | 0.57  | -0.0  | 1.21  | -0.94 | 1.45  | -1.05 | -0.41 | -0.55 | -0.10 |
| 50 | -1.41 | 3.21 | 0.30  | 0.08  | 1.07  | -0.04 | 1.17  | -1.33 | 0.20  | -0.21 | 0.32  |
| 51 | -0.33 | 3.50 | 0.30  | -1.56 | 1.49  | -0.54 | 1.19  | -0.82 | -0.01 | 0.35  | 0.11  |
| 52 | -0.54 | 3.27 | -1.11 | -0.18 | 0.61  | 0.93  | -0.24 | -0.30 | 0.79  | 0.17  | -0.12 |
| 53 | -1.52 | 4.00 | -3.48 | 0.01  | 0.90  | 1.59  | -1.71 | 1.19  | -1.07 | -0.44 | -0.69 |
| 54 | -1.00 | 3.35 | -2.51 | -0.88 | 0.76  | 1.13  | -0.92 | 0.61  | -0.94 | -0.15 | -0.48 |
| 55 | -1.35 | 3.10 | -2.03 | -1.97 | 1.12  | 0.85  | -0.99 | 0.36  | -0.83 | 0.27  | 0.27  |
| 56 | -1.86 | 3.05 | -2.29 | -2.24 | 1.44  | -0.28 | -0.04 | -0.09 | -1.16 | 1.06  | 0.18  |
| 57 | -1.96 | 2.89 | -2.00 | -2.41 | 1.47  | -0.96 | 0.70  | -0.75 | -0.35 | 0.62  | -0.35 |
| 58 | -2.49 | 2.57 | -2.12 | -2.37 | 1.31  | -0.93 | 0.70  | -0.38 | 0.56  | -0.43 | -0.16 |
| 59 | -2.68 | 2.76 | -2.29 | -1.89 | 1.44  | -0.73 | 1.00  | 0.04  | 0.75  | -0.83 | 0.56  |
| 60 | -2.72 | 2.70 | -2.33 | -1.69 | 1.41  | -0.55 | 0.72  | 0.10  | 0.12  | -0.50 | 0.42  |
| 61 | -1.93 | 2.34 | -1.95 | -1.25 | 1.00  | -0.08 | 0.55  | -0.58 | -0.75 | -0.18 | 0.08  |
| 62 | -1.87 | 1.44 | -1.64 | -0.76 | 0.47  | 0.17  | 0.12  | -0.93 | -0.62 | 0.06  | -0.32 |
| 63 | -1.04 | 0.83 | -0.88 | 0.10  | 0.09  | 0.29  | -0.55 | -1.23 | 0.21  | 0.05  | -0.25 |
| 64 | -1.29 | 0.55 | -0.62 | 0.41  | 0.34  | 0.60  | -0.35 | -0.77 | 0.89  | -0.11 | -0.14 |





Table C.2. cont'

|    |       |       |       |       |       |       |       |       |       |       |       |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 65 | -0.61 | 0.88  | -0.08 | 0.89  | 1.19  | 0.57  | 0.12  | -0.20 | 0.86  | -0.40 | -0.05 |
| 66 | -0.67 | 0.70  | 0.13  | 1.24  | 1.44  | 0.39  | 0.37  | 0.25  | 0.52  | -0.46 | 0.19  |
| 67 | -0.61 | 0.38  | 0.88  | 1.56  | 2.44  | -0.14 | 0.84  | -0.37 | -0.48 | 0.24  | 0.46  |
| 68 | -1.04 | 0.12  | 1.32  | 1.55  | 2.54  | -0.35 | 0.38  | -1.16 | -0.46 | 0.84  | -0.33 |
| 69 | -0.61 | -0.04 | 1.36  | 1.16  | 2.17  | -0.49 | -0.51 | -1.33 | -0.03 | 0.43  | -0.21 |
| 70 | -0.82 | -0.07 | 1.33  | 0.64  | 1.81  | -0.66 | -1.26 | -0.51 | 0.55  | -0.23 | 0.25  |
| 71 | -0.45 | -0.17 | 1.54  | -0.11 | 1.51  | -1.22 | -1.27 | 0.12  | 0.62  | -0.48 | 0.18  |
| 72 | -0.60 | -0.12 | 1.80  | -0.98 | 1.31  | -1.82 | -0.86 | 0.18  | 0.06  | -0.53 | -0.09 |
| 73 | -0.44 | -0.28 | 1.47  | -1.57 | 1.34  | -1.75 | -0.05 | 0.03  | -0.06 | -0.42 | -0.18 |
| 74 | -0.85 | -0.07 | 0.67  | -1.64 | 1.40  | -1.38 | 0.61  | -0.13 | 0.27  | -0.60 | 0.12  |
| 75 | -0.70 | 0.62  | 0.31  | -1.77 | 1.09  | -1.08 | 0.90  | -0.27 | 0.82  | -0.69 | 0.19  |
| 76 | -1.48 | 0.88  | -0.28 | -1.58 | 1.10  | -0.73 | 1.16  | -0.36 | 0.52  | -0.44 | -0.15 |
| 77 | -1.53 | 1.15  | -0.74 | -0.99 | 0.65  | -0.40 | 1.08  | -0.34 | -0.25 | 0.48  | -0.28 |
| 78 | -2.60 | 1.90  | -1.26 | -0.40 | -0.06 | -0.62 | 0.89  | -0.45 | -0.01 | 0.59  | -0.02 |
| 79 | -2.67 | 2.23  | -1.45 | -0.17 | -0.33 | 0.39  | 0.51  | 0.20  | 0.03  | 0.19  | -0.06 |
| 80 | -3.21 | 2.84  | -1.86 | -0.06 | -0.50 | 0.50  | 0.39  | 0.33  | -0.0  | 0.24  | 0.11  |
| 81 | -3.83 | 3.35  | -2.21 | 0.61  | -1.37 | 1.22  | -0.04 | 0.74  | 0.25  | -0.09 | 0.12  |
| 82 | -3.80 | 3.75  | -2.46 | 0.36  | -0.82 | 1.60  | -0.04 | 1.17  | -0.01 | -0.05 | 0.16  |
| 83 | -3.09 | 3.96  | -2.67 | -0.02 | -0.44 | 1.94  | -0.18 | 1.00  | -1.04 | 0.04  | -0.03 |
| 84 | -2.99 | 3.82  | -2.90 | -0.44 | 0.05  | 1.88  | -0.11 | 0.52  | -1.26 | 0.23  | -0.13 |
| 85 | -2.18 | 4.03  | -2.35 | -0.96 | 0.36  | 1.32  | 0.57  | 0.49  | -0.63 | 0.24  | -0.11 |
| 86 | -2.22 | 3.77  | -2.50 | -1.22 | 0.46  | 1.17  | 0.22  | 0.22  | -0.84 | 0.04  | -0.14 |
| 87 | -1.31 | 4.14  | -2.04 | -1.88 | 1.21  | 0.82  | 1.33  | -0.02 | -0.24 | 0.40  | -0.17 |
| 88 | -1.44 | 3.74  | -2.16 | -2.03 | 0.79  | 0.42  | 0.52  | -0.06 | -0.46 | -0.16 | -0.21 |
| 89 | -1.07 | 3.66  | -2.39 | -2.02 | 0.26  | 0.55  | -0.01 | 0.54  | -0.73 | -0.49 | 0.42  |
| 90 | -1.51 | 3.29  | -2.84 | -1.57 | -0.26 | 0.33  | 0.04  | 0.66  | -0.77 | -0.11 | 0.72  |
| 91 | -0.14 | 2.64  | -0.91 | -2.26 | -0.80 | 0.37  | 0.85  | 0.87  | -0.41 | -0.10 | 0.60  |
| 92 | -0.68 | 1.84  | -2.15 | -1.41 | -0.32 | -0.11 | 0.62  | -0.31 | 0.35  | -0.31 | 0.06  |
| 93 | -0.45 | 1.34  | -1.51 | -1.42 | 0.11  | -0.09 | 0.15  | -0.69 | 0.63  | -0.21 | -0.19 |
| 94 | -0.52 | 1.03  | -0.88 | -1.65 | 0.84  | 0.16  | -0.06 | -0.55 | 0.87  | 0.13  | -0.50 |
| 95 | -0.49 | 0.38  | -0.32 | -2.16 | 0.75  | 0.39  | -0.02 | 0.10  | 0.45  | 0.14  | 0.11  |
| 96 | -0.47 | 0.16  | 0.20  | -3.10 | 1.56  | 0.09  | -0.16 | 0.39  | 0.30  | 0.29  | 0.56  |
| 97 | -1.01 | 0.47  | 0.64  | -4.01 | 2.42  | -0.36 | -0.47 | 0.69  | -0.44 | 0.27  | 0.08  |
| 98 | -1.30 | -0.40 | 0.42  | -3.96 | 2.38  | -0.23 | 0.13  | -0.09 | -0.58 | 0.32  | -0.31 |
| 99 | -1.16 | -0.24 | 0.28  | -3.65 | 1.97  | 0.03  | 0.37  | 0.30  | -0.41 | 0.15  | -0.08 |





Table C.2. cont<sup>6</sup>

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 100 | -1.29 | 0.39  | 0.53  | -3.26 | 1.60  | -0.19 | 0.53  | 0.17  | -0.13 | -0.24 | 0.14  |
| 101 | -0.65 | 1.44  | 1.14  | -2.43 | 0.84  | -0.38 | 0.54  | 0.30  | -0.05 | -0.23 | 0.19  |
| 102 | -2.39 | 1.05  | -0.93 | -1.79 | 0.70  | 0.88  | 0.13  | -0.53 | 0.53  | -0.31 | 0.13  |
| 103 | -2.59 | 0.62  | -1.50 | -1.56 | 1.13  | 1.15  | -0.59 | -0.72 | 0.64  | -0.23 | 0.0   |
| 104 | -2.69 | 0.94  | -2.69 | -1.65 | 0.90  | 1.55  | -1.11 | -0.59 | 0.49  | 0.27  | -0.18 |
| 105 | -2.34 | 1.30  | -3.17 | -2.01 | 0.61  | 1.50  | -1.51 | -0.02 | 0.11  | 0.23  | -0.36 |
| 106 | -2.26 | 1.18  | -3.26 | -2.15 | 0.89  | 1.41  | -1.50 | 0.86  | 0.13  | 0.28  | 0.06  |
| 107 | -1.53 | 1.40  | -3.28 | -1.80 | 1.27  | 1.61  | -1.47 | 0.83  | -0.03 | 0.05  | 0.28  |
| 108 | -1.75 | 1.48  | -3.69 | -0.66 | 1.61  | 1.42  | -1.10 | 0.44  | -0.16 | -0.24 | 0.28  |
| 109 | -1.32 | 1.24  | -4.73 | 0.0   | 1.87  | 1.07  | -0.55 | 0.12  | 0.14  | -0.03 | 0.33  |
| 110 | -0.80 | 1.47  | -5.27 | 0.53  | 1.98  | 0.17  | -0.25 | 0.10  | 0.68  | -0.05 | 0.01  |
| 111 | 0.40  | 1.57  | -5.35 | 0.39  | 2.00  | -0.55 | 0.04  | 0.18  | 0.83  | -0.60 | -0.02 |
| 112 | 0.55  | 1.71  | -5.16 | 0.04  | 1.71  | -1.06 | 0.21  | -0.45 | 0.56  | -0.54 | 0.06  |
| 113 | 1.40  | 2.84  | -3.34 | -0.71 | 1.99  | -0.65 | 0.52  | -0.28 | 0.25  | 0.14  | -0.17 |
| 114 | 0.48  | 2.74  | -2.90 | -0.74 | 2.00  | -0.65 | 0.25  | -0.62 | 0.20  | 0.45  | 0.06  |
| 115 | 0.19  | 1.64  | -2.70 | -0.77 | 2.22  | -0.74 | 0.61  | -0.67 | 0.38  | 0.18  | -0.24 |
| 116 | -0.37 | 1.47  | -3.28 | -0.15 | 2.05  | -1.13 | 0.74  | -0.77 | 0.63  | -0.64 | -0.01 |
| 117 | -0.34 | 1.11  | -4.02 | -0.28 | 1.78  | -0.85 | 0.57  | -0.62 | 0.59  | -0.31 | 0.04  |
| 118 | -0.52 | 0.83  | -4.09 | 0.17  | 1.32  | -0.54 | -0.18 | -0.0  | -0.34 | 0.40  | 0.22  |
| 119 | 0.22  | 0.97  | -4.07 | 0.44  | 1.04  | -0.57 | 0.0   | -0.05 | -0.85 | 0.91  | -0.07 |
| 120 | 0.31  | 0.60  | -4.40 | -0.03 | 0.51  | -0.22 | 0.47  | 0.18  | -1.17 | 0.78  | -0.56 |
| 121 | 0.15  | 1.18  | -4.52 | -0.88 | 0.01  | 0.87  | 0.05  | 0.65  | 0.17  | -0.14 | 0.26  |
| 122 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 123 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 124 | -0.17 | 1.49  | -4.72 | -1.97 | 0.05  | 1.31  | -0.87 | 0.51  | -0.28 | -0.67 | -0.17 |
| 125 | -0.39 | 1.67  | -4.27 | -2.42 | 0.74  | 1.05  | -0.63 | 0.11  | -0.09 | -0.37 | 0.14  |
| 126 | -0.23 | 2.30  | -3.44 | -2.88 | 1.23  | 0.53  | -0.61 | -0.16 | 0.02  | -0.15 | 0.27  |
| 127 | -0.37 | 2.71  | -2.44 | -3.04 | 1.97  | 0.29  | -0.18 | -0.19 | 0.16  | -0.05 | 0.04  |
| 128 | -0.55 | 3.04  | -1.43 | -3.15 | 2.70  | 0.12  | 0.32  | -0.14 | 0.25  | 0.09  | -0.21 |
| 129 | -0.61 | 3.25  | -0.84 | -2.73 | 3.04  | 0.71  | 1.01  | -0.28 | 0.50  | -0.25 | 0.03  |
| 130 | -1.09 | 3.25  | -0.39 | -2.11 | 3.10  | 0.68  | 1.25  | -0.35 | 0.52  | -0.72 | 0.17  |
| 131 | -0.67 | 3.48  | -0.46 | -1.61 | 3.05  | 0.63  | 1.25  | -0.67 | 0.04  | -0.36 | -0.21 |
| 132 | -0.52 | 3.45  | -0.17 | -1.72 | 3.01  | -0.14 | 0.84  | -0.59 | -0.54 | -0.14 | -0.20 |
| 133 | -0.01 | 3.45  | -0.39 | -1.96 | 2.84  | -0.49 | -0.06 | -0.46 | -0.76 | -0.05 | 0.61  |
| 134 | 0.07  | 3.55  | -0.37 | -2.27 | 2.70  | -0.85 | -0.20 | -0.69 | -0.69 | 0.12  | 0.20  |



Table C.2, cont'

|     |       |       |       |       |      |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|-------|
| 135 | -0.05 | 3.50  | -0.61 | -2.21 | 2.51 | -1.06 | 0.22  | -0.58 | -0.14 | -0.02 | -0.07 |
| 136 | -0.20 | 3.47  | -0.75 | -2.21 | 2.29 | -1.28 | 0.69  | -0.40 | 0.46  | -0.18 | -0.34 |
| 137 | -0.22 | 3.30  | -1.58 | -1.61 | 2.07 | -0.76 | 0.93  | 0.14  | 0.67  | -0.18 | -0.26 |
| 138 | -0.38 | 3.23  | -2.75 | -1.64 | 1.52 | -0.53 | 0.98  | 0.30  | -0.14 | -0.30 | -0.36 |
| 139 | -0.23 | 2.61  | -3.55 | -1.33 | 1.01 | 0.13  | 0.71  | 0.45  | -0.71 | 0.20  | -0.10 |
| 140 | -0.77 | 2.32  | -3.73 | -1.22 | 0.82 | 0.70  | 0.43  | 0.05  | -0.56 | 0.48  | 0.11  |
| 141 | -0.77 | 2.32  | -3.73 | -1.22 | 0.82 | 0.70  | 0.43  | 0.05  | -0.56 | 0.48  | 0.11  |
| 142 | -1.37 | 1.21  | -3.65 | -0.42 | 1.30 | 2.16  | 0.24  | -0.43 | 0.70  | -0.17 | -0.25 |
| 143 | -1.02 | 1.38  | -3.14 | 0.06  | 1.29 | 2.16  | -0.31 | -0.64 | 0.44  | -0.79 | -0.14 |
| 144 | -1.41 | 1.73  | -2.95 | 0.15  | 1.31 | 1.91  | -0.83 | -0.41 | -0.44 | -0.25 | -0.19 |
| 145 | -0.93 | 1.87  | -3.18 | 0.23  | 1.34 | 1.41  | -0.93 | -0.21 | -0.61 | 0.24  | -0.37 |
| 146 | -0.85 | 1.75  | -3.72 | -0.10 | 1.29 | 0.69  | -0.22 | -0.25 | -0.20 | -0.22 | -0.12 |
| 147 | -0.85 | 1.64  | -4.17 | -0.45 | 1.25 | 0.08  | 0.35  | -0.33 | 0.28  | -0.66 | 0.11  |
| 148 | -1.16 | 1.83  | -4.35 | -0.54 | 1.22 | -0.50 | 0.54  | -0.33 | -0.16 | -0.15 | 0.09  |
| 149 | -0.71 | 1.87  | -4.13 | 0.03  | 1.22 | -0.61 | -0.21 | -0.42 | -0.55 | 0.49  | -0.34 |
| 150 | -0.33 | 1.80  | -3.93 | 0.42  | 0.98 | -1.04 | -0.76 | -1.17 | -0.12 | 0.20  | 0.46  |
| 151 | 0.40  | 1.49  | -4.05 | 0.87  | 0.57 | -1.19 | -0.83 | -0.68 | 0.69  | 0.04  | 0.18  |
| 152 | 0.20  | 1.11  | -4.36 | 1.15  | 0.63 | -0.47 | -0.74 | 0.11  | 0.44  | 0.30  | -0.66 |
| 153 | 0.51  | 0.95  | -4.12 | 1.38  | 0.46 | 0.42  | -0.63 | 0.21  | -0.26 | 0.34  | -0.52 |
| 154 | -0.35 | 0.93  | -4.05 | 1.49  | 0.26 | 1.23  | -0.52 | 0.17  | -0.47 | -0.03 | -0.15 |
| 155 | -1.03 | 1.27  | -4.19 | 1.43  | 0.26 | 0.96  | 0.18  | -0.13 | -0.57 | 0.01  | 0.01  |
| 156 | -0.68 | 0.28  | -3.56 | 1.02  | 0.29 | 0.77  | 0.60  | -0.17 | -0.52 | -0.10 | 0.05  |
| 157 | -0.15 | -0.02 | -2.97 | 1.05  | 0.55 | 0.20  | 0.99  | -0.26 | -0.25 | 0.30  | -0.20 |
| 158 | -0.03 | -0.59 | -2.16 | 0.76  | 0.72 | -0.0  | 1.53  | 0.11  | -0.10 | 0.24  | -0.30 |
| 159 | 0.56  | -0.76 | -2.07 | 0.44  | 0.96 | 0.22  | 1.22  | -0.24 | -0.02 | -0.03 | 0.08  |
| 160 | 0.63  | -0.87 | -1.98 | 0.05  | 0.86 | -0.06 | 0.15  | -0.65 | 0.12  | -0.10 | 0.33  |
| 161 | 0.77  | -1.06 | -1.83 | 0.09  | 1.11 | -0.05 | -0.60 | -0.56 | 0.55  | 0.26  | -0.17 |
| 162 | 0.09  | -0.67 | -2.07 | -0.02 | 1.22 | 0.16  | -1.01 | -0.11 | 0.22  | 0.20  | -0.24 |
| 163 | -0.08 | -0.46 | -2.25 | -0.20 | 1.75 | 0.12  | -1.03 | 0.34  | -0.06 | -0.49 | 0.28  |
| 164 | -0.86 | -0.01 | -2.84 | -0.41 | 2.08 | 0.46  | -1.18 | 0.41  | -0.30 | -0.37 | 0.26  |
| 165 | -0.56 | 0.06  | -3.18 | -0.70 | 2.72 | 0.88  | -1.42 | 0.22  | -0.44 | 0.20  | -0.0  |
| 166 | -1.19 | 0.02  | -2.82 | -0.83 | 3.27 | 1.30  | -1.14 | -0.33 | -0.16 | 0.12  | -0.06 |
| 167 | -0.67 | 0.10  | -2.59 | -0.58 | 3.22 | 1.61  | -0.76 | -0.30 | 0.11  | -0.17 | -0.12 |
| 168 | -0.81 | 0.30  | -1.50 | -0.56 | 2.44 | 1.78  | -0.17 | -0.33 | -0.22 | -0.09 | -0.03 |
| 169 | -1.07 | 0.78  | -1.62 | -0.72 | 2.23 | 1.73  | -0.33 | -0.37 | -0.35 | -0.02 | -0.04 |



Table C.2. cont'

|     |       |      |       |       |       |       |       |       |       |       |       |
|-----|-------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 170 | -2.16 | 1.02 | -1.23 | -0.57 | 1.73  | 1.08  | -0.14 | -0.29 | 0.01  | -0.21 | -0.06 |
| 171 | -2.30 | 1.50 | -1.34 | -0.56 | 0.85  | 0.54  | 0.33  | -0.28 | 0.25  | -0.02 | -0.05 |
| 172 | -2.93 | 1.66 | -1.26 | -0.64 | 0.24  | -0.23 | 0.81  | -0.46 | 0.28  | -0.25 | -0.28 |
| 173 | -3.04 | 1.85 | -1.54 | -0.10 | 0.10  | 0.01  | 0.75  | -0.79 | 0.12  | -0.16 | -0.19 |
| 174 | -3.67 | 1.84 | -2.08 | 0.26  | -0.05 | -0.23 | -0.32 | -0.81 | 0.06  | 0.33  | 0.13  |
| 175 | -3.08 | 1.52 | -2.17 | 0.53  | 0.40  | -0.21 | -1.16 | -0.74 | -0.34 | 0.55  | -0.29 |
| 176 | -3.50 | 1.23 | -2.27 | 0.68  | 0.91  | -0.20 | -1.39 | -0.33 | -0.48 | 0.36  | -0.0  |
| 177 | -2.73 | 1.11 | -1.90 | 0.71  | 1.70  | -0.72 | -0.91 | 0.33  | 0.09  | -0.14 | 0.39  |
| 178 | -2.45 | 1.15 | -1.07 | 0.62  | 2.49  | -1.48 | -0.28 | 0.85  | 0.16  | -0.14 | 0.29  |
| 179 | -2.07 | 1.17 | -0.24 | 0.80  | 2.89  | -1.68 | 0.18  | 0.99  | 0.02  | -0.01 | -0.16 |
| 180 | -2.17 | 1.47 | 0.57  | 0.30  | 3.53  | -1.83 | 0.76  | 0.62  | 0.50  | 0.24  | -0.09 |
| 181 | -1.93 | 2.00 | 0.90  | 0.12  | 3.45  | -1.58 | 1.20  | -0.52 | 0.36  | -0.16 | -0.09 |
| 182 | -2.18 | 2.84 | 0.59  | -0.36 | 2.40  | -1.58 | 1.00  | -1.53 | 0.14  | -0.14 | 0.03  |
| 183 | -1.69 | 3.12 | 0.18  | -0.66 | 0.92  | -1.28 | 0.59  | -0.92 | 0.48  | 0.51  | 0.13  |
| 184 | -1.85 | 2.49 | -0.30 | -0.71 | -0.42 | -0.89 | 0.26  | 0.01  | 0.90  | 0.19  | -0.23 |
| 185 | -1.19 | 2.06 | -0.85 | -1.14 | -0.90 | -0.32 | -0.27 | 0.52  | 0.22  | -0.15 | -0.35 |
| 186 | -0.34 | 1.54 | -1.38 | -1.54 | -0.43 | -0.02 | -0.50 | 1.20  | -1.00 | 0.42  | -0.34 |
| 187 | -0.78 | 1.61 | -1.44 | -1.83 | -0.38 | 0.64  | -0.91 | 1.09  | -0.85 | -0.04 | 0.30  |
| 188 | -1.12 | 1.47 | -1.36 | -1.60 | -0.36 | 1.02  | -0.67 | 1.10  | -0.53 | 0.45  | -0.44 |
| 189 | -0.24 | 1.62 | -1.34 | -0.78 | -0.11 | 1.81  | -0.22 | -0.50 | 0.14  | 0.38  | -0.32 |
| 190 | -0.55 | 1.27 | -1.41 | -0.41 | -0.20 | 2.38  | -0.53 | -0.60 | 0.37  | 0.03  | -0.01 |
| 191 | 0.36  | 1.16 | -1.15 | -0.18 | -1.00 | 2.17  | -1.11 | -0.78 | 0.23  | -0.11 | 0.01  |
| 192 | -0.33 | 0.73 | -1.32 | -0.28 | -1.50 | 1.72  | -1.35 | -0.18 | 0.06  | 0.06  | -0.10 |
| 193 | -0.06 | 0.61 | -1.79 | -0.20 | -1.88 | 0.86  | -1.04 | 0.84  | -0.08 | 0.24  | -0.12 |
| 194 | -0.99 | 0.62 | -2.20 | 0.11  | -1.82 | 0.17  | -0.44 | 1.32  | -0.38 | 0.23  | -0.46 |
| 195 | -1.00 | 1.33 | -2.30 | 0.91  | -2.03 | -0.63 | 0.19  | 0.98  | -0.78 | 0.31  | -0.30 |
| 196 | -1.93 | 1.70 | -2.15 | 1.46  | -1.86 | -1.25 | 0.96  | 0.10  | -0.10 | 0.25  | 0.06  |
| 197 | -1.85 | 1.64 | -1.76 | 2.18  | -1.39 | -0.75 | 1.39  | -0.70 | 0.25  | -0.08 | 0.18  |
| 198 | -2.35 | 1.31 | -1.54 | 2.83  | -0.76 | 0.06  | 1.52  | -1.38 | 0.47  | 0.27  | 0.46  |
| 199 | -1.65 | 1.28 | -1.40 | 3.55  | -0.26 | 0.85  | 1.71  | -1.17 | 0.39  | 0.39  | 0.14  |
| 200 | -1.43 | 0.88 | -1.14 | 3.94  | 0.42  | 1.79  | 1.98  | -0.86 | 0.03  | -0.06 | -0.01 |
| 201 | -0.08 | 1.11 | -0.98 | 4.11  | 1.08  | 2.16  | 1.29  | -0.73 | -0.14 | -0.51 | 0.12  |
| 202 | -0.24 | 0.87 | -0.83 | 3.83  | 1.15  | 2.31  | -0.40 | -0.07 | -0.26 | -0.40 | 0.26  |
| 203 | 0.71  | 1.04 | -1.13 | 3.77  | 0.91  | 1.87  | -1.42 | -0.04 | 0.35  | 0.03  | 0.16  |
| 204 | -0.03 | 0.51 | -1.75 | 2.86  | 0.48  | 1.60  | -0.76 | 0.13  | 0.22  | 0.58  | -0.62 |





Table C.2. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 205 | 0.13  | 0.40  | -1.58 | 2.64  | -0.40 | 0.60  | -0.34 | 0.31  | -0.11 | 0.34  | -0.66 |
| 206 | -1.17 | 0.23  | -1.96 | 2.23  | -1.32 | -0.50 | 0.02  | 0.54  | 0.46  | -0.09 | -0.46 |
| 207 | -1.54 | 0.14  | -2.59 | 2.24  | -1.52 | -1.28 | -0.36 | 0.64  | 0.41  | 0.07  | 0.17  |
| 208 | -3.09 | -0.05 | -3.17 | 2.08  | -0.55 | -1.53 | -0.70 | 0.76  | -0.08 | 0.23  | -0.08 |
| 209 | -2.75 | 0.22  | -3.67 | 2.13  | 0.21  | -1.46 | -0.37 | 0.35  | -0.67 | -0.04 | -0.16 |
| 210 | -3.32 | 0.62  | -3.94 | 1.81  | 0.94  | -0.88 | 0.20  | 0.26  | 0.10  | -0.27 | 0.17  |
| 211 | -2.61 | 1.31  | -3.37 | 2.01  | 1.13  | 0.12  | 0.48  | 0.82  | 1.12  | -0.09 | -0.10 |
| 212 | -2.59 | 1.28  | -2.68 | 1.31  | 1.50  | 1.10  | 1.25  | 0.49  | 0.55  | 0.45  | -0.33 |
| 213 | -1.71 | 1.64  | -1.88 | 0.53  | 1.76  | 1.57  | 1.56  | -0.26 | -0.29 | 0.40  | 0.28  |
| 214 | -1.49 | 1.57  | -1.08 | -0.20 | 1.79  | 1.46  | 1.15  | -0.99 | -0.68 | -0.06 | 0.31  |
| 215 | 0.08  | 1.48  | -0.42 | -0.55 | 1.13  | 0.55  | 0.04  | -1.69 | 0.06  | 0.36  | -0.25 |
| 216 | 0.15  | 1.09  | 0.09  | -1.03 | -0.15 | -0.46 | -0.37 | -1.04 | 0.78  | 0.36  | -0.20 |
| 217 | 1.15  | 1.58  | 0.62  | -1.19 | -1.49 | -0.94 | -0.64 | 0.51  | 0.82  | -0.19 | -0.09 |
| 218 | 0.33  | 1.76  | 0.42  | -1.46 | -2.30 | -1.03 | -0.67 | 1.13  | 0.33  | -0.16 | -0.37 |
| 219 | 0.52  | 2.16  | 0.11  | -1.50 | -2.76 | -0.56 | -0.61 | 0.73  | 0.09  | -0.60 | 0.03  |
| 220 | -0.39 | 2.19  | 0.13  | -1.48 | -2.80 | -0.14 | -0.32 | 0.14  | -0.31 | -0.63 | 0.74  |
| 221 | -0.13 | 2.07  | 0.58  | -1.27 | -2.67 | -0.02 | -0.13 | 0.02  | -0.55 | 0.11  | 0.45  |
| 222 | -0.88 | 1.92  | 0.86  | -1.41 | -2.99 | -0.28 | -0.03 | 0.40  | -0.23 | 0.52  | -0.40 |
| 223 | -0.39 | 2.00  | 0.51  | -1.82 | -2.80 | -0.26 | -0.02 | 0.40  | 0.39  | 0.07  | -0.47 |
| 224 | -1.00 | 1.69  | 0.34  | -2.38 | -2.13 | -0.36 | 0.74  | -0.19 | 0.45  | -0.47 | -0.11 |
| 225 | -0.65 | 1.79  | 0.18  | -2.49 | -1.57 | -0.75 | 1.30  | -0.36 | 0.39  | -0.73 | -0.03 |
| 226 | -1.62 | 2.20  | 0.61  | -2.43 | -0.96 | -1.52 | 1.66  | -0.36 | 0.26  | -0.30 | 0.05  |
| 227 | -1.53 | 2.81  | 0.61  | -2.51 | -1.01 | -1.63 | 1.79  | -0.36 | 0.06  | 0.16  | 0.23  |
| 228 | -2.17 | 3.25  | 0.75  | -2.48 | -1.10 | -1.44 | 1.55  | -0.91 | -0.10 | 0.23  | 0.13  |
| 229 | -1.55 | 3.75  | 0.81  | -2.19 | -1.21 | -0.86 | 1.01  | -1.03 | 0.01  | -0.12 | -0.06 |
| 230 | -2.49 | 3.69  | 0.92  | -1.98 | -1.15 | -0.50 | 0.82  | -0.64 | -0.28 | 0.10  | 0.21  |
| 231 | -2.05 | 4.20  | 0.91  | -2.02 | -1.16 | 0.06  | 0.94  | -0.20 | -0.69 | 0.14  | 0.13  |
| 232 | -3.04 | 3.99  | 1.04  | -1.94 | -1.27 | 0.34  | 1.55  | -0.17 | -0.54 | -0.02 | -0.17 |
| 233 | -2.71 | 4.12  | 1.39  | -1.72 | -1.48 | 0.58  | 1.29  | 0.13  | -0.35 | -0.22 | 0.02  |
| 234 | -3.83 | 3.86  | 1.47  | -1.66 | -1.15 | 0.57  | 0.80  | 0.41  | -0.15 | -0.38 | 0.38  |
| 235 | -3.33 | 3.89  | 1.22  | -1.23 | -0.66 | 0.04  | 0.45  | 0.49  | -0.18 | 0.02  | 0.18  |
| 236 | -4.04 | 3.51  | 0.69  | -1.10 | -0.38 | -0.90 | -0.34 | 0.44  | -0.12 | 0.18  | -0.21 |
| 237 | -3.32 | 3.27  | 0.40  | -0.46 | -0.01 | -1.55 | -1.34 | 0.24  | -0.09 | 0.03  | -0.15 |
| 238 | -3.84 | 2.69  | 0.16  | -0.44 | 0.32  | -2.14 | -1.62 | 0.10  | -0.36 | 0.11  | -0.25 |
| 239 | -2.90 | 2.55  | -0.15 | 0.02  | 0.21  | -2.79 | -1.79 | 0.07  | -0.73 | 0.30  | -0.33 |
| 240 | -3.66 | 2.39  | -0.49 | 0.21  | 0.67  | -3.10 | -0.94 | 0.03  | -0.97 | 0.17  | -0.46 |





## APPENDIX D

(Northern Data Set)

Figure D.1. to D.11.

Amplitude versus Time for space-waves of wave number 1 to 11, respectively. Time is indicated as days after Dec. 1, 1976.

Table D.1.

Values of AAMPL for NUMB = 240.

Table D.2.

Values of BAMPL for NUMB = 240.



Figure D.1.

Wave Number 1

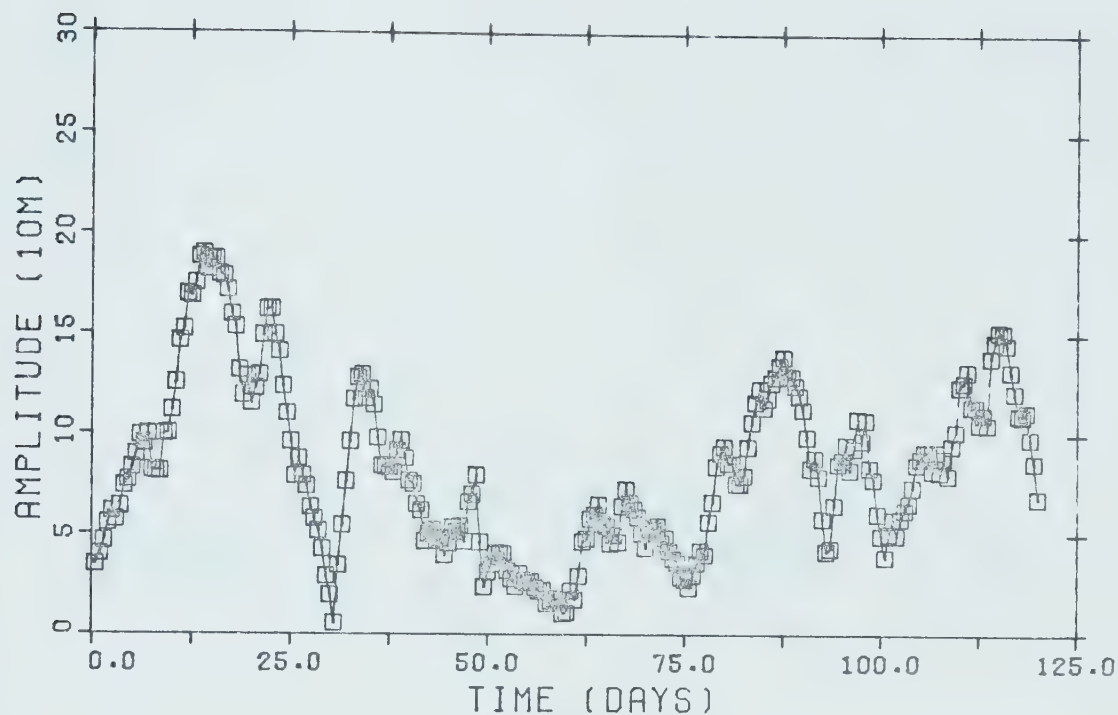


Figure D.2.

Wave Number 2

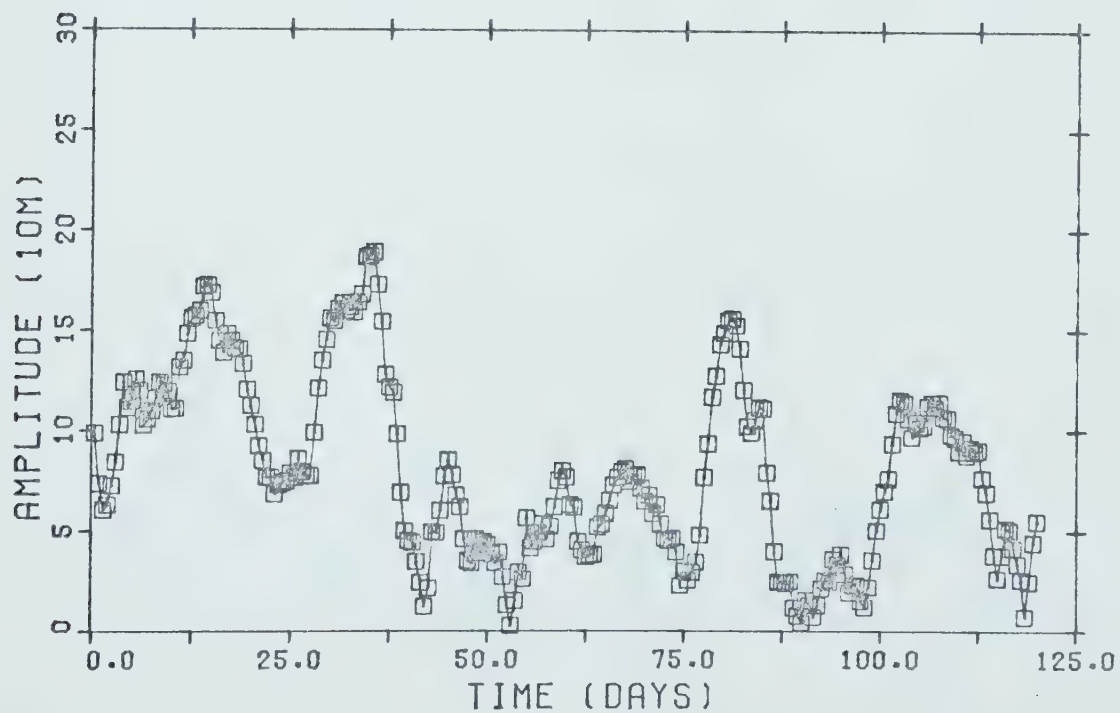




Figure D.3.

Wave Number 3

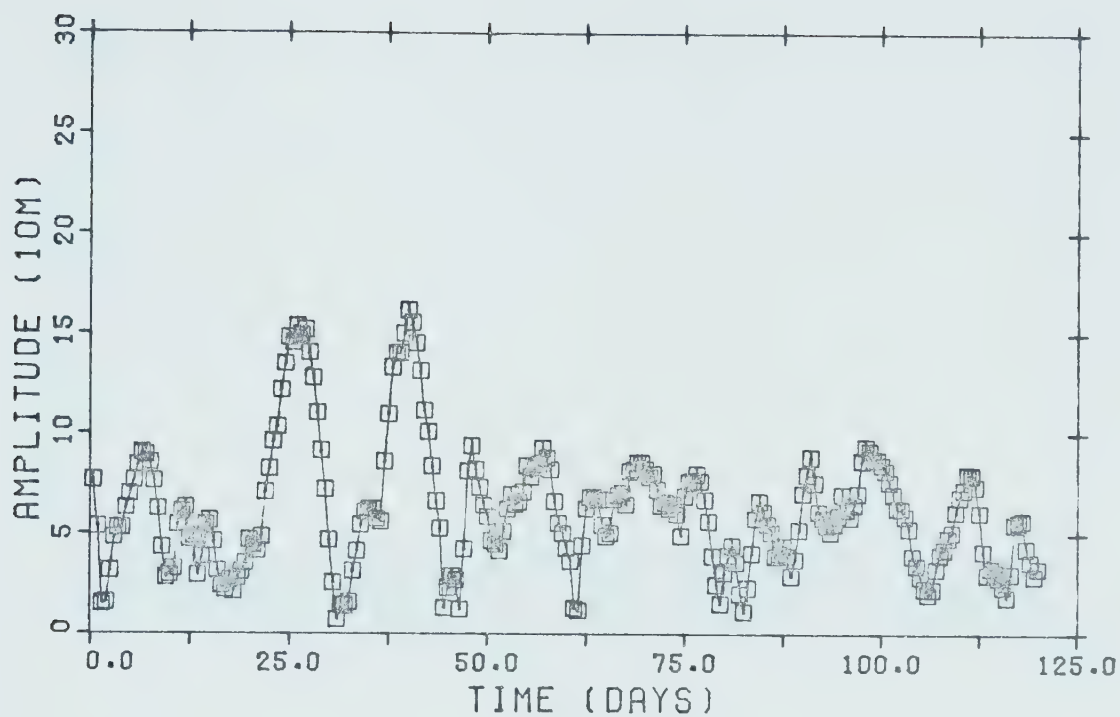


Figure D.4.

Wave Number 4

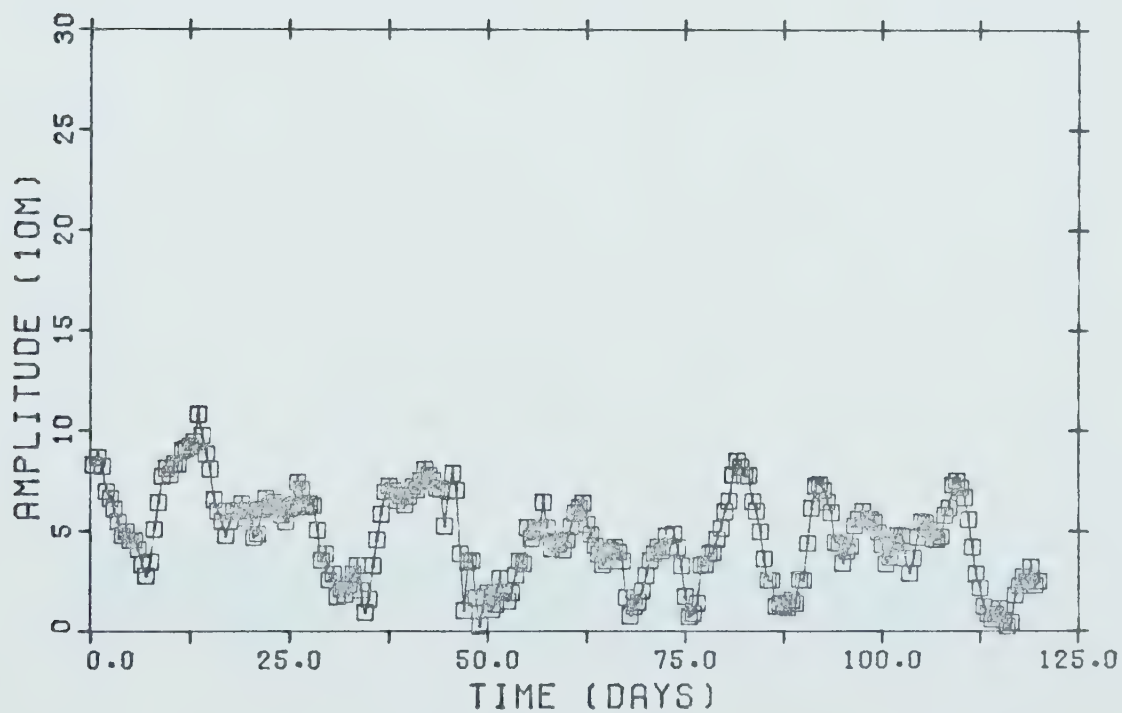




Figure D.5.

Wave Number 5

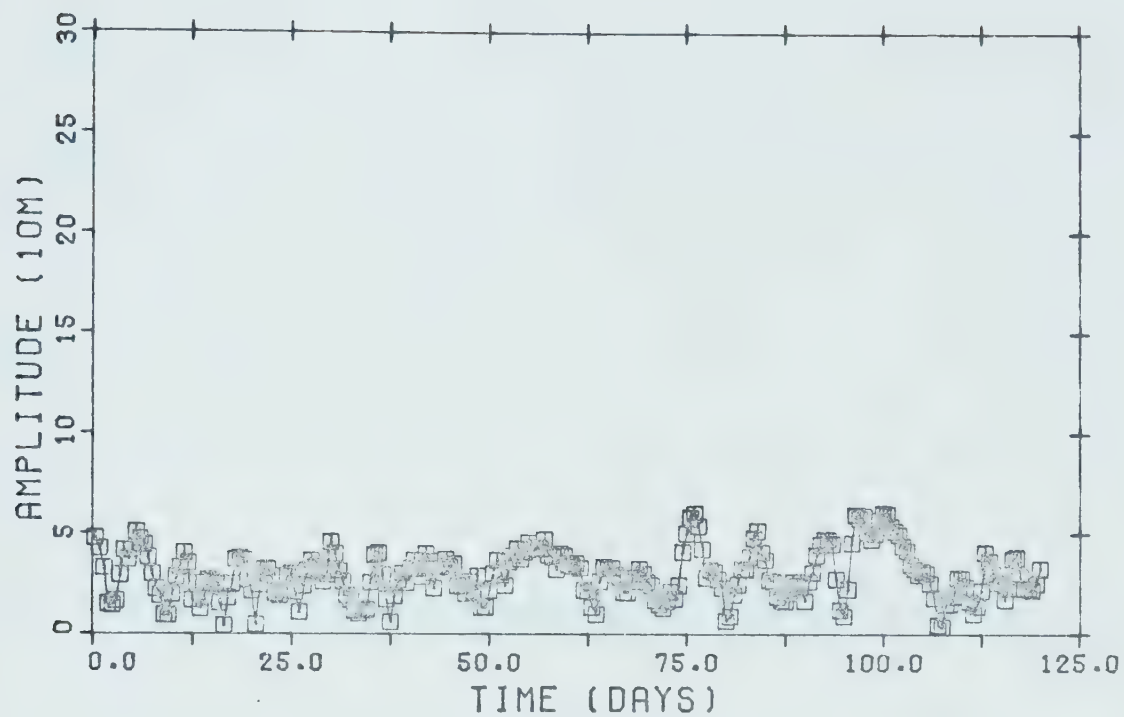


Figure D.6.

Wave Number 6

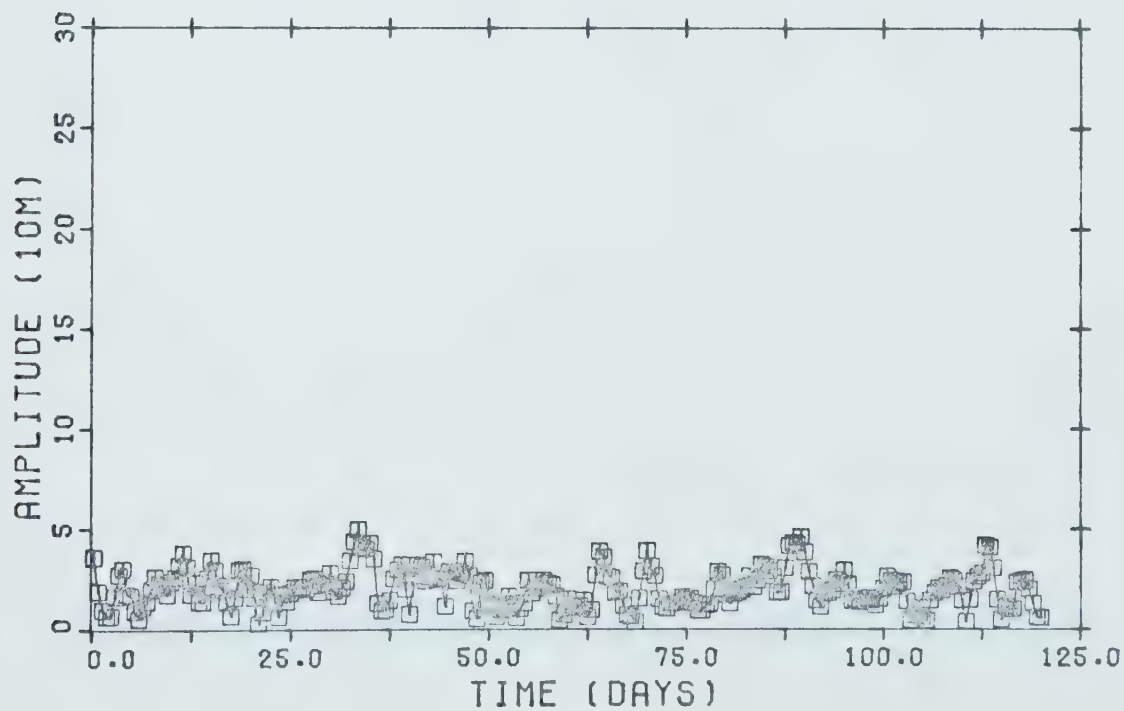






Figure D.7.

Wave Number 7

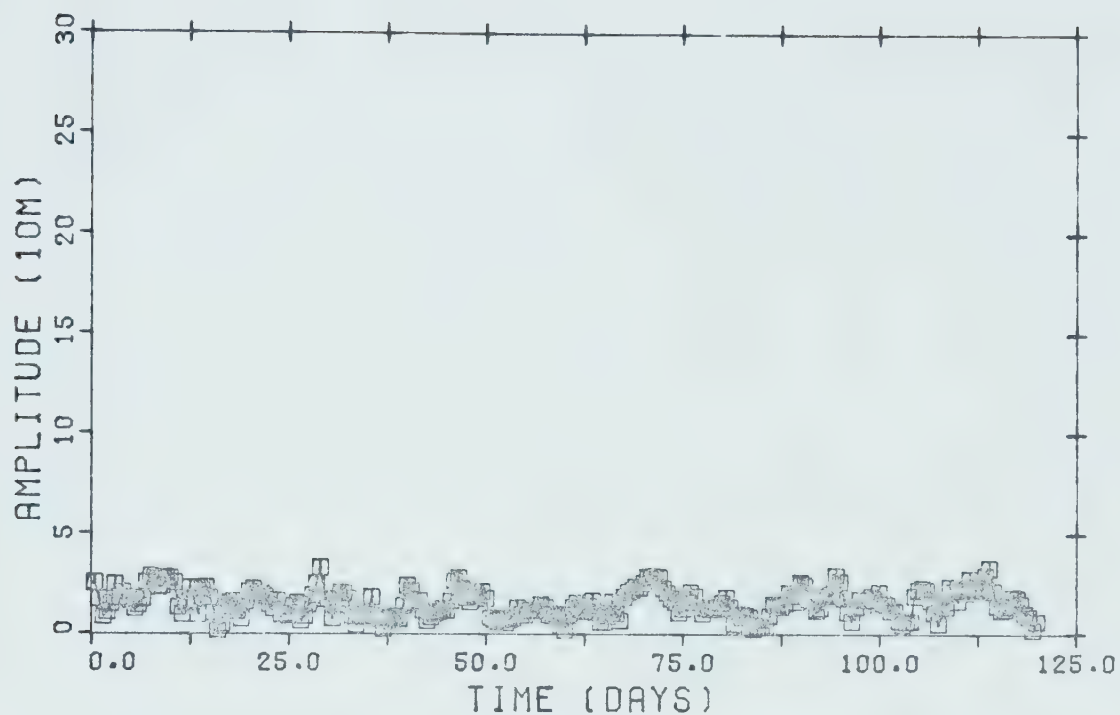


Figure D.8.

Wave Number 8

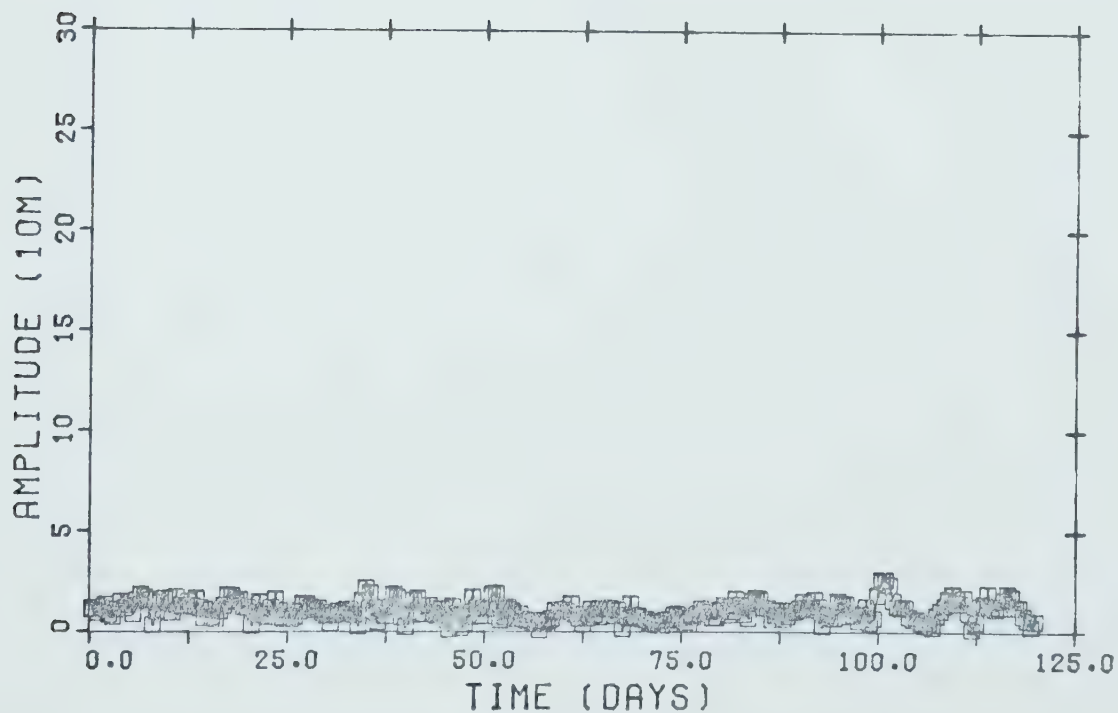




Figure D.9.

Wave Number 9

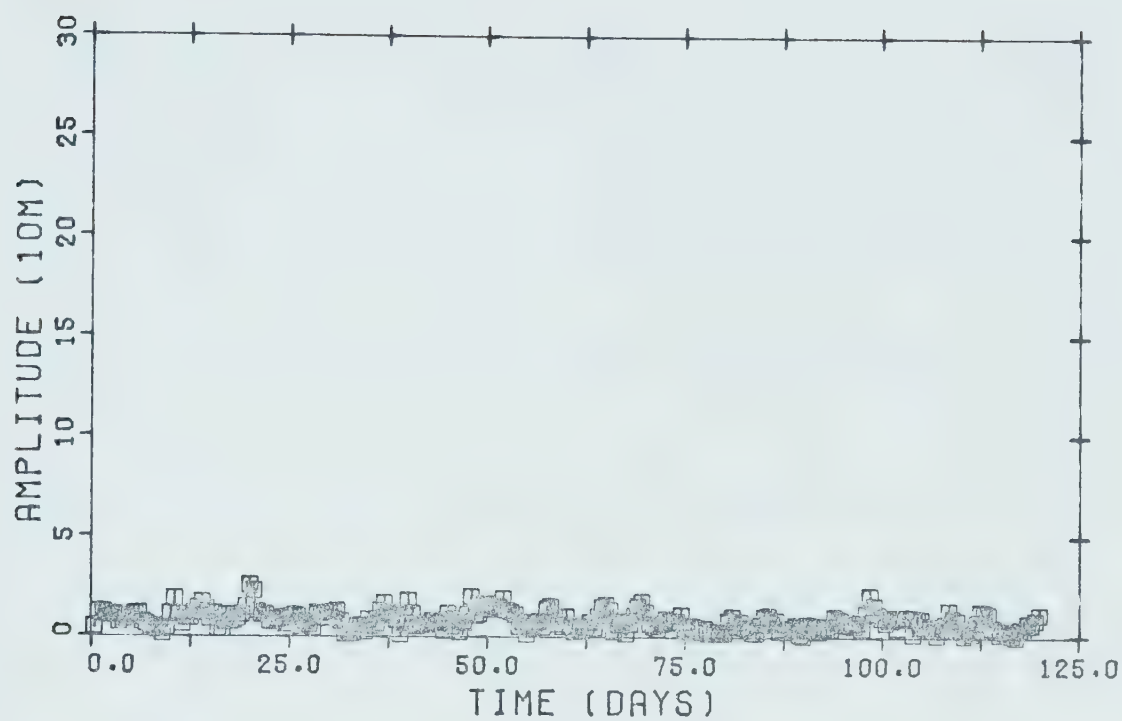


Figure D.10.

Wave Number 10

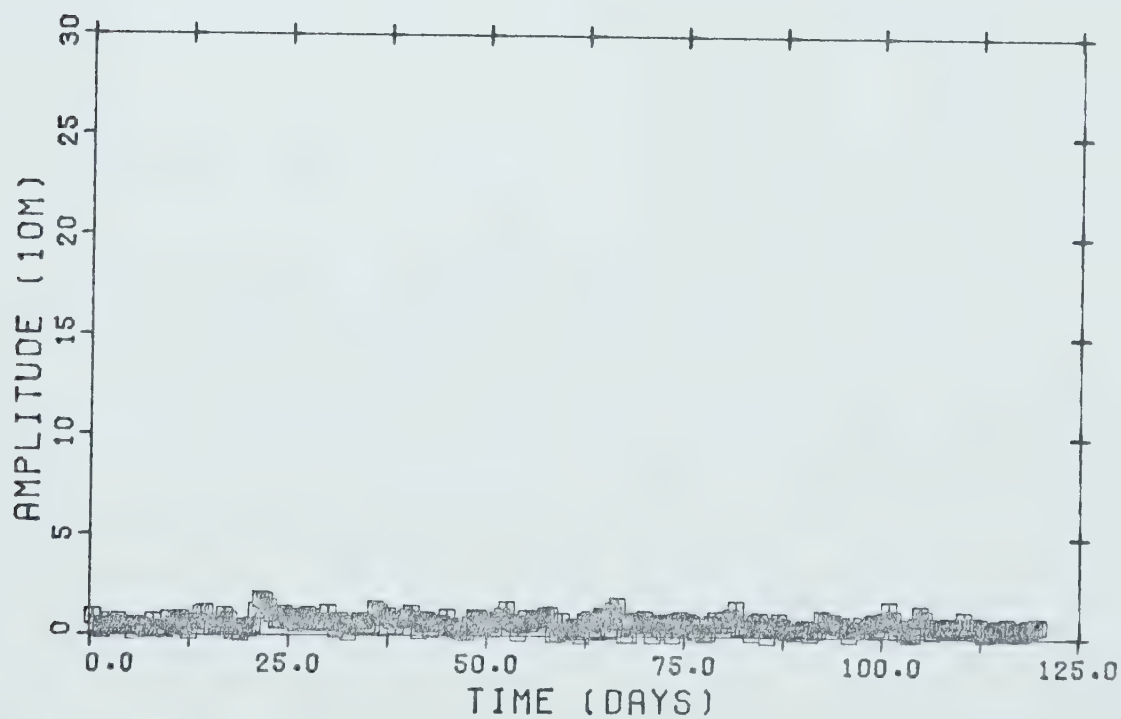




Figure D.11.

Wave Number 11

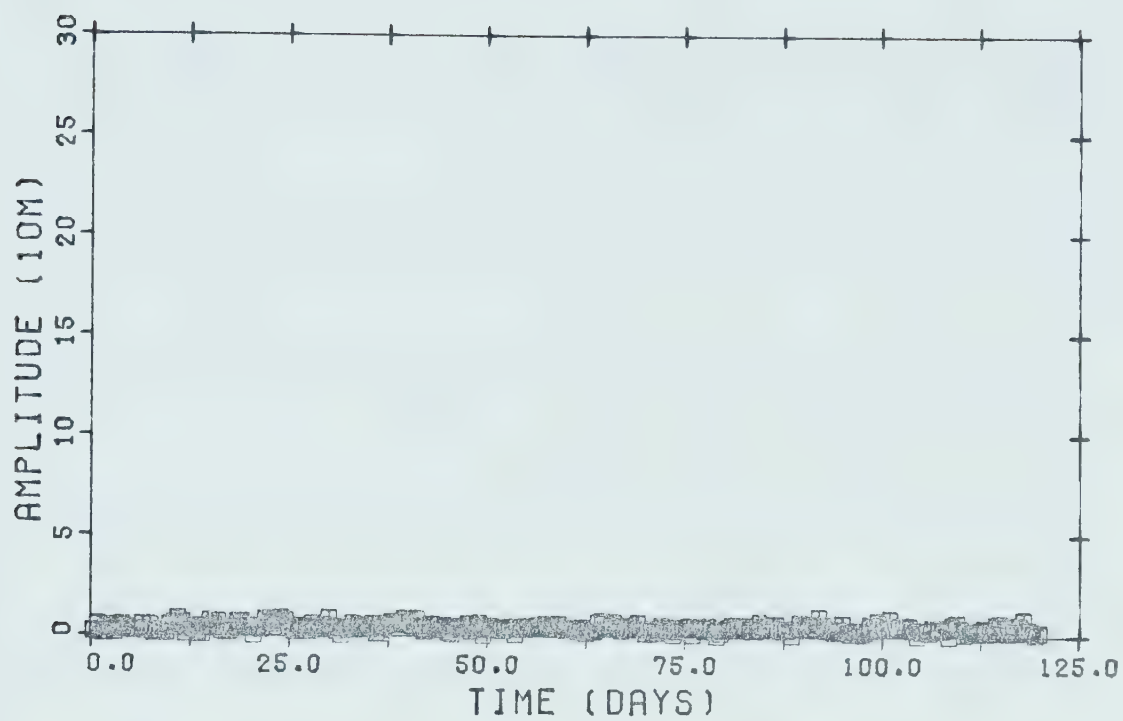




Table D.1. Values of AAMPL for NUMB = 240

Wave Number

| Row | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1   | 1.48  | -3.37 | -1.89 | 3.66  | -1.24 | -1.68 | -1.08 | 0.47  | -0.14 | 0.41  | 0.01  |
| 2   | 1.74  | -3.13 | -0.88 | 3.89  | -1.32 | -0.91 | -0.45 | 0.03  | -0.48 | 0.05  | -0.16 |
| 3   | 1.96  | -2.86 | -0.54 | 3.81  | -1.30 | 0.13  | 0.26  | -0.54 | -0.62 | 0.02  | -0.05 |
| 4   | 2.58  | -2.89 | -0.58 | 3.16  | -0.63 | 0.31  | 0.53  | -0.47 | -0.10 | 0.19  | -0.16 |
| 5   | 2.96  | -3.16 | -0.59 | 2.87  | -0.63 | 0.31  | 0.75  | -0.11 | 0.29  | -0.09 | -0.25 |
| 6   | 2.85  | -3.46 | -1.16 | 2.49  | -0.81 | 0.80  | 0.96  | 0.32  | 0.52  | -0.22 | -0.04 |
| 7   | 3.09  | -3.87 | -1.55 | 2.43  | -0.79 | 1.32  | -0.21 | 0.54  | 0.21  | -0.11 | 0.15  |
| 8   | 3.36  | -4.65 | -1.39 | 2.15  | 0.06  | 1.01  | -0.99 | 0.73  | -0.20 | 0.22  | -0.06 |
| 9   | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 10  | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 11  | 3.69  | -5.59 | -1.61 | 1.55  | 2.51  | -0.21 | -0.25 | 0.06  | 0.12  | -0.01 | 0.01  |
| 12  | 3.86  | -5.60 | -1.83 | 1.46  | 2.28  | -0.28 | -0.10 | 0.51  | -0.32 | -0.24 | 0.15  |
| 13  | 3.56  | -4.60 | -2.17 | 1.30  | 1.91  | -0.35 | -0.06 | 0.80  | -0.31 | 0.04  | 0.11  |
| 14  | 3.61  | -4.18 | -2.19 | 1.23  | 1.32  | -0.39 | 0.30  | 0.84  | -0.15 | 0.14  | 0.01  |
| 15  | 2.06  | -3.57 | -2.12 | 1.59  | 0.82  | -0.15 | 1.07  | 0.75  | 0.20  | -0.09 | -0.25 |
| 16  | 1.02  | -3.06 | -2.00 | 2.51  | 0.32  | 0.22  | 1.37  | 0.05  | -0.07 | -0.25 | 0.04  |
| 17  | -0.25 | -2.69 | -1.95 | 3.22  | 0.03  | 0.32  | 0.71  | -0.36 | 0.08  | 0.03  | -0.10 |
| 18  | -0.05 | -1.66 | -1.56 | 3.78  | -0.21 | 0.67  | -0.38 | -0.26 | 0.06  | -0.02 | -0.04 |
| 19  | -0.38 | -1.38 | -1.27 | 3.86  | -0.02 | 0.88  | -1.38 | 0.19  | -0.07 | 0.05  | -0.01 |
| 20  | -1.34 | -1.91 | -1.48 | 3.50  | 0.51  | 0.66  | -1.07 | 0.45  | -0.54 | 0.39  | -0.05 |
| 21  | -0.91 | -0.77 | -1.28 | 3.82  | 0.95  | 0.17  | -0.41 | -0.36 | -0.48 | -0.04 | -0.03 |
| 22  | -1.95 | -1.08 | -1.85 | 3.82  | 1.39  | -0.52 | 0.0   | -0.85 | 0.17  | -0.28 | 0.33  |
| 23  | -2.06 | -1.36 | -1.00 | 4.20  | 1.96  | -0.88 | 0.32  | -0.57 | 0.25  | -0.21 | 0.17  |
| 24  | -2.94 | -2.40 | -0.08 | 4.22  | 1.70  | -1.12 | 0.72  | -0.60 | 0.04  | -0.18 | -0.03 |
| 25  | -3.93 | -3.09 | 0.58  | 4.52  | 0.66  | -0.64 | 1.14  | -0.75 | -0.23 | -0.08 | 0.14  |
| 26  | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 27  | -5.72 | -3.25 | -0.09 | 5.25  | 0.14  | -0.13 | -0.10 | -0.23 | -0.10 | -0.14 | -0.09 |
| 28  | -6.16 | -2.92 | -0.26 | 4.74  | -0.02 | 0.24  | -1.05 | 0.45  | -0.55 | 0.36  | 0.03  |
| 29  | -5.86 | -2.46 | -0.42 | 4.36  | -0.50 | -0.19 | -0.65 | 0.25  | -0.68 | 0.45  | -0.16 |





Table D.1. cont'

|    |       |       |       |       |       |       |       |       |       |       |       |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 30 | -5.86 | -2.39 | -0.21 | 3.99  | -0.67 | -1.34 | 0.47  | 0.40  | -0.07 | -0.11 | -0.03 |
| 31 | -6.39 | -1.99 | 0.24  | 3.28  | -0.40 | -1.47 | 0.51  | 0.35  | 0.22  | -0.13 | -0.04 |
| 32 | -6.28 | -2.60 | 0.53  | 3.00  | -0.12 | -1.10 | -0.08 | 0.15  | 0.04  | -0.02 | -0.17 |
| 33 | -6.53 | -2.67 | 0.43  | 2.74  | -0.17 | -0.85 | 0.20  | -0.34 | -0.17 | -0.23 | 0.04  |
| 34 | -6.69 | -2.64 | 0.91  | 2.37  | -0.84 | -0.50 | 0.47  | -0.64 | -0.48 | -0.47 | 0.04  |
| 35 | -6.67 | -1.66 | 1.34  | 2.59  | -1.19 | 0.10  | 0.16  | -0.61 | -0.35 | -0.37 | 0.09  |
| 36 | -6.66 | -1.47 | 1.06  | 2.84  | -1.84 | 0.65  | -0.41 | -0.15 | -0.37 | -0.07 | 0.10  |
| 37 | -5.99 | -1.24 | 1.26  | 2.72  | -1.84 | 0.81  | -0.53 | 0.36  | -0.29 | -0.02 | -0.29 |
| 38 | -5.42 | -1.56 | 0.96  | 3.01  | -1.79 | 0.50  | -0.28 | 0.70  | -0.43 | -0.01 | -0.33 |
| 39 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 40 | -4.90 | -1.85 | 0.44  | 3.00  | -1.07 | 0.20  | 0.84  | 0.50  | -1.13 | 0.06  | 0.01  |
| 41 | -5.17 | -1.49 | -0.24 | 2.29  | 0.21  | 0.06  | 1.13  | -0.15 | -0.50 | 0.02  | 0.01  |
| 42 | -5.43 | -1.35 | -1.04 | 2.07  | 0.88  | 0.02  | 0.92  | -0.21 | 0.16  | -0.34 | -0.21 |
| 43 | -6.75 | -0.58 | -1.76 | 2.50  | 0.84  | -0.21 | 0.91  | 0.02  | 0.53  | -0.83 | -0.01 |
| 44 | -7.38 | -0.44 | -2.92 | 2.66  | 0.75  | 0.24  | 0.81  | 0.16  | 0.31  | -0.82 | 0.29  |
| 45 | -7.53 | 0.20  | -3.36 | 2.70  | 0.70  | 0.62  | 0.51  | 0.13  | -0.14 | -0.30 | 0.35  |
| 46 | -7.15 | 1.43  | -4.25 | 2.84  | 0.53  | 0.63  | 0.58  | -0.08 | -0.33 | 0.18  | 0.10  |
| 47 | -6.97 | 2.11  | -4.77 | 2.74  | 0.95  | -0.11 | 0.82  | -0.19 | -0.17 | -0.05 | -0.08 |
| 48 | -6.15 | 2.90  | -5.87 | 2.77  | 1.06  | -0.74 | 0.45  | -0.12 | 0.20  | -0.21 | -0.41 |
| 49 | -5.51 | 3.50  | -6.69 | 2.73  | 1.17  | -0.56 | 0.37  | -0.05 | 0.04  | -0.43 | -0.32 |
| 50 | -4.72 | 3.90  | -7.37 | 3.06  | 1.23  | -0.65 | 0.42  | -0.18 | 0.03  | -0.38 | -0.06 |
| 51 | -3.67 | 3.79  | -7.27 | 3.10  | 0.97  | -1.05 | 0.70  | -0.17 | -0.45 | -0.32 | -0.02 |
| 52 | -3.91 | 4.14  | -7.67 | 3.50  | 0.49  | -1.04 | 0.76  | 0.19  | -0.22 | -0.03 | 0.16  |
| 53 | -3.12 | 3.48  | -7.33 | 3.38  | 0.68  | -0.99 | 0.15  | 0.0   | -0.23 | 0.33  | -0.20 |
| 54 | -3.11 | 2.53  | -7.32 | 3.03  | 0.60  | -1.00 | -0.36 | 0.03  | -0.16 | 0.21  | -0.05 |
| 55 | -3.03 | 1.11  | -6.64 | 3.15  | 0.38  | -1.24 | -0.45 | 0.33  | 0.07  | -0.31 | 0.01  |
| 56 | -2.84 | -0.54 | -5.75 | 3.14  | 0.24  | -1.26 | 0.02  | 0.57  | 0.18  | -0.43 | 0.23  |
| 57 | -2.57 | -2.21 | -4.52 | 2.50  | 0.56  | -0.67 | 0.97  | 0.48  | 0.10  | -0.02 | 0.15  |
| 58 | -2.10 | -3.68 | -3.52 | 1.78  | 0.63  | -0.72 | 1.40  | 0.49  | -0.21 | 0.06  | 0.13  |
| 59 | -1.35 | -4.78 | -2.44 | 1.80  | 0.91  | -0.65 | 0.82  | 0.26  | -0.37 | -0.25 | 0.19  |
| 60 | -0.96 | -6.29 | -1.40 | 1.09  | 0.85  | -0.68 | 0.86  | 0.40  | -0.36 | -0.45 | 0.17  |
| 61 | 0.02  | -7.02 | -1.07 | 0.79  | 0.14  | -0.04 | 0.05  | -0.04 | -0.28 | -0.26 | 0.17  |
| 62 | 0.45  | -7.86 | 0.32  | 0.45  | -0.36 | 0.82  | 0.02  | -0.0  | -0.47 | -0.01 | -0.09 |
| 63 | 0.42  | -8.18 | 0.71  | 0.95  | -1.00 | 1.01  | -0.29 | 0.24  | -0.37 | 0.27  | -0.02 |
| 64 | 0.73  | -7.91 | 0.45  | 0.90  | -0.90 | 1.17  | -0.65 | 0.45  | -0.03 | 0.13  | 0.18  |



Table D.1. cont'

|    |       |       |       |       |       |       |       |       |       |       |       |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 65 | -0.22 | -7.56 | -0.46 | 1.03  | -0.85 | 1.69  | -0.81 | 0.27  | 0.07  | -0.06 | 0.16  |
| 66 | -0.99 | -6.82 | -0.79 | 1.30  | -0.47 | 1.93  | -0.43 | -0.33 | -0.07 | 0.23  | 0.30  |
| 67 | -1.98 | -5.93 | -0.83 | 1.26  | -0.05 | 1.84  | -0.17 | -0.26 | 0.26  | -0.06 | 0.19  |
| 68 | -2.73 | -5.18 | -0.84 | 0.65  | 0.39  | 1.33  | 0.47  | -0.13 | 0.12  | -0.33 | 0.20  |
| 69 | -3.43 | -5.38 | 0.26  | 0.37  | 0.62  | 1.08  | 0.43  | -0.67 | 0.11  | 0.17  | 0.15  |
| 70 | -4.10 | -5.85 | 0.20  | 0.52  | 1.21  | 0.73  | 0.45  | -1.01 | 0.31  | 0.24  | 0.16  |
| 71 | -4.38 | -6.31 | 0.20  | 0.79  | 1.70  | -0.05 | 0.78  | -0.89 | 0.27  | 0.19  | 0.09  |
| 72 | -4.29 | -5.95 | -0.93 | 1.04  | 1.03  | -0.13 | 0.14  | -0.26 | 0.29  | -0.14 | -0.06 |
| 73 | -4.10 | -5.12 | -2.13 | 1.74  | 0.16  | -0.08 | 0.26  | 0.14  | 0.05  | -0.58 | -0.02 |
| 74 | -4.17 | -3.66 | -3.97 | 2.53  | -0.45 | 0.36  | 0.03  | 0.56  | -0.75 | -0.28 | 0.18  |
| 75 | -4.14 | -2.77 | -5.23 | 2.89  | -0.24 | 0.24  | -0.06 | 0.05  | -0.57 | 0.17  | 0.16  |
| 76 | -4.04 | -1.52 | -6.40 | 3.11  | -0.04 | -0.36 | -0.0  | -0.48 | -0.38 | 0.33  | -0.17 |
| 77 | -4.52 | -0.61 | -6.85 | 2.99  | 0.99  | -1.28 | 0.36  | -0.89 | 0.22  | 0.18  | -0.10 |
| 78 | -4.72 | -0.08 | -6.97 | 2.79  | 1.49  | -1.59 | -0.04 | -0.80 | 0.01  | 0.33  | -0.36 |
| 79 | -4.31 | 0.51  | -7.50 | 2.59  | 1.05  | -0.87 | -0.38 | -0.27 | -0.19 | 0.17  | -0.30 |
| 80 | -3.78 | 1.60  | -8.00 | 3.00  | 0.66  | 0.28  | -0.73 | -0.10 | -0.68 | -0.11 | 0.01  |
| 81 | -3.66 | 2.10  | -7.44 | 3.11  | 1.00  | 1.33  | -0.44 | 0.46  | -0.52 | -0.07 | 0.20  |
| 82 | -3.21 | 1.72  | -6.53 | 2.78  | 1.10  | 1.57  | -0.61 | 0.77  | -0.25 | 0.19  | 0.26  |
| 83 | -3.08 | 1.16  | -5.71 | 2.57  | 0.81  | 1.42  | -0.84 | 0.82  | -0.31 | 0.01  | 0.01  |
| 84 | -2.27 | 0.30  | -4.85 | 2.26  | 1.17  | 1.06  | -0.58 | 0.28  | -0.23 | -0.28 | -0.05 |
| 85 | -2.32 | -0.67 | -4.51 | 1.57  | 1.01  | 1.27  | -0.16 | -0.12 | -0.02 | -0.37 | 0.08  |
| 86 | -2.39 | -2.44 | -3.34 | 0.76  | 0.74  | 1.35  | 0.02  | -0.39 | -0.08 | -0.14 | 0.06  |
| 87 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 88 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 89 | -0.94 | -3.70 | -0.60 | 1.13  | -0.23 | 0.29  | -0.62 | -0.31 | -0.05 | -0.12 | 0.24  |
| 90 | -1.44 | -3.77 | -0.59 | 2.35  | 0.25  | 0.96  | -0.44 | 0.12  | 0.17  | -0.28 | 0.05  |
| 91 | -2.28 | -3.06 | -0.62 | 2.70  | 0.53  | 0.86  | 0.19  | 0.03  | 0.29  | -0.06 | -0.02 |
| 92 | -2.36 | -2.27 | -0.80 | 1.91  | 0.36  | 0.68  | 0.45  | 0.41  | -0.07 | 0.05  | -0.16 |
| 93 | -2.68 | -1.44 | 0.12  | 0.75  | 0.0   | 0.50  | 0.29  | 0.28  | -0.0  | 0.09  | 0.11  |
| 94 | -2.08 | -1.02 | 1.16  | 0.45  | -0.02 | 0.45  | -0.45 | -0.08 | 0.35  | 0.02  | 0.07  |
| 95 | -2.75 | -1.05 | 1.94  | 1.02  | -0.06 | 0.46  | -0.63 | -0.08 | 0.53  | -0.02 | 0.01  |
| 96 | -2.79 | -1.38 | 1.74  | 1.21  | 0.08  | 0.43  | -0.62 | -0.38 | 0.94  | -0.21 | -0.11 |
| 97 | -3.65 | -2.13 | 0.09  | 0.05  | -0.93 | -0.02 | -0.96 | -0.75 | 0.23  | -0.37 | 0.12  |
| 98 | -1.65 | -1.40 | -0.20 | -0.04 | 0.06  | 1.13  | -0.82 | -0.55 | 0.37  | -0.10 | 0.17  |
| 99 | -0.61 | -0.72 | -1.50 | -0.47 | 0.49  | 1.19  | -1.05 | -0.21 | 0.46  | -0.17 | -0.01 |



Table D.1. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 100 | 0.38  | -0.51 | -1.96 | -0.72 | 0.68  | 0.52  | -0.77 | 0.03  | 0.22  | -0.36 | 0.18  |
| 101 | 0.39  | 0.49  | -1.84 | -0.27 | 0.79  | 0.37  | -0.30 | 0.31  | -0.03 | -0.16 | 0.10  |
| 102 | -0.09 | 0.67  | -1.83 | 0.33  | 0.95  | 0.28  | -0.16 | 0.24  | 0.08  | 0.0   | 0.16  |
| 103 | -0.29 | 1.34  | -0.76 | 1.00  | 0.67  | -0.12 | -0.24 | 0.63  | -0.44 | 0.12  | 0.13  |
| 104 | -0.42 | 1.14  | 0.33  | 0.70  | 0.66  | -0.52 | -0.30 | 0.16  | -0.93 | 0.49  | 0.13  |
| 105 | -0.97 | 0.48  | 1.28  | 0.51  | 1.47  | -0.67 | -0.09 | 0.36  | -0.46 | 0.26  | -0.20 |
| 106 | -0.65 | -0.08 | 1.36  | 0.58  | 1.91  | -0.28 | -0.12 | 0.43  | -0.25 | -0.02 | -0.03 |
| 107 | -0.81 | -0.73 | 0.29  | 0.67  | 2.10  | -0.07 | -0.32 | 0.32  | 0.17  | 0.14  | 0.05  |
| 108 | -0.29 | -1.29 | -0.50 | 0.77  | 1.78  | -0.21 | -0.65 | 0.31  | 0.17  | 0.04  | -0.04 |
| 109 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 110 | 0.07  | -2.17 | -2.56 | 0.39  | 2.26  | -1.03 | -0.45 | -0.27 | -0.03 | 0.13  | 0.24  |
| 111 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 112 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 113 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 114 | 1.10  | -1.99 | -4.64 | 0.30  | 1.45  | -1.00 | -0.67 | 0.04  | 0.24  | -0.42 | 0.26  |
| 115 | 0.76  | -1.56 | -4.30 | 0.66  | 0.70  | -0.71 | -0.65 | -0.21 | 0.62  | -0.46 | 0.27  |
| 116 | 0.49  | -2.01 | -3.91 | 1.27  | -0.09 | 0.21  | -0.48 | -0.09 | 0.54  | -0.43 | 0.27  |
| 117 | 0.41  | -2.37 | -3.19 | 1.96  | -0.50 | 0.27  | -0.43 | -0.20 | 0.18  | -0.01 | 0.14  |
| 118 | 0.21  | -2.89 | -2.59 | 1.97  | -1.10 | 0.08  | -0.27 | -0.29 | 0.32  | 0.06  | 0.15  |
| 119 | 0.01  | -2.75 | -2.40 | 1.92  | -1.03 | -0.0  | -0.12 | 0.08  | 0.17  | 0.29  | 0.13  |
| 120 | -0.26 | -2.64 | -1.91 | 2.13  | -0.80 | -0.40 | 0.03  | 0.25  | 0.15  | 0.11  | -0.16 |
| 121 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 122 | -0.41 | -1.92 | -0.46 | 2.86  | -1.19 | -0.39 | -0.14 | 0.21  | 0.14  | -0.22 | 0.08  |
| 123 | -0.15 | -1.06 | 0.06  | 2.96  | -1.48 | 0.05  | -0.31 | 0.29  | 0.02  | -0.10 | -0.05 |
| 124 | -0.58 | -1.00 | -0.01 | 2.94  | -1.09 | 0.24  | -0.28 | 0.22  | -0.17 | 0.01  | -0.04 |
| 125 | -0.04 | -1.47 | -0.19 | 2.08  | -1.02 | -0.13 | -0.25 | -0.10 | -0.05 | 0.31  | 0.02  |
| 126 | 1.13  | -1.71 | -0.10 | 1.45  | -0.64 | -0.46 | -0.67 | -0.32 | 0.08  | 0.32  | -0.10 |
| 127 | 1.29  | -1.90 | 0.04  | 0.91  | -0.20 | -0.87 | -0.83 | -0.37 | 0.09  | 0.13  | 0.13  |
| 128 | 1.30  | -2.60 | 0.27  | 1.05  | 0.15  | -1.27 | -0.53 | -0.0  | -0.11 | -0.02 | 0.34  |
| 129 | 0.87  | -2.67 | 0.40  | 0.81  | 0.42  | -1.32 | 0.17  | 0.27  | -0.57 | 0.15  | 0.29  |
| 130 | 0.71  | -2.83 | 0.19  | 0.81  | 0.64  | -0.70 | 0.29  | 0.56  | -0.76 | 0.40  | 0.11  |
| 131 | 0.22  | -3.07 | 0.12  | 1.23  | 1.03  | -0.71 | 0.36  | 0.57  | -0.45 | -0.11 | 0.09  |
| 132 | -0.76 | -3.55 | 0.05  | 1.29  | 1.15  | -0.78 | 0.51  | 0.53  | -0.13 | -0.56 | 0.32  |
| 133 | -1.56 | -3.77 | 0.16  | 0.90  | 0.98  | -0.91 | 0.33  | 0.27  | -0.09 | -0.21 | 0.13  |
| 134 | -2.94 | -3.88 | -1.07 | 0.89  | 0.38  | -0.22 | -0.03 | 0.30  | -0.36 | 0.11  | -0.14 |





Table D.1. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 135 | -3.59 | -3.77 | -1.29 | 0.49  | -0.14 | -0.35 | 0.06  | 0.03  | -0.09 | -0.05 | -0.03 |
| 136 | -3.25 | -3.58 | -2.38 | 0.06  | -0.57 | -0.32 | 0.41  | -0.14 | 0.24  | 0.03  | 0.22  |
| 137 | -3.09 | -3.61 | -2.45 | -0.24 | -0.66 | -0.03 | 0.63  | 0.08  | -0.29 | 0.38  | -0.16 |
| 138 | -2.92 | -3.73 | -2.62 | -0.06 | -0.72 | 0.64  | 0.76  | 0.17  | -0.78 | 0.25  | -0.15 |
| 139 | -2.48 | -3.40 | -2.41 | 0.15  | -0.71 | 0.53  | 0.82  | -0.29 | -0.71 | -0.17 | 0.12  |
| 140 | -2.16 | -3.02 | -1.99 | 0.38  | -0.67 | -0.22 | 1.12  | -0.19 | -0.38 | -0.43 | -0.02 |
| 141 | -2.61 | -3.14 | -2.12 | 0.67  | -0.38 | -0.63 | 1.43  | -0.22 | -0.20 | -0.27 | -0.13 |
| 142 | -2.29 | -2.75 | -1.85 | 1.19  | 0.09  | -0.96 | 1.39  | -0.18 | -0.14 | -0.03 | -0.07 |
| 143 | -2.53 | -2.89 | -1.79 | 1.43  | 0.45  | -0.74 | 1.10  | -0.16 | 0.06  | -0.16 | -0.05 |
| 144 | -2.02 | -2.63 | -2.24 | 1.26  | 0.38  | -0.15 | 0.68  | -0.01 | 0.19  | -0.34 | 0.08  |
| 145 | -2.24 | -2.31 | -2.57 | 1.37  | 0.46  | 0.20  | -0.42 | -0.08 | 0.41  | -0.13 | 0.19  |
| 146 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 147 | -1.85 | -2.24 | -2.20 | 1.36  | 0.34  | 0.49  | -0.85 | 0.0   | 0.05  | 0.04  | 0.05  |
| 148 | -1.48 | -1.85 | -1.65 | 1.07  | 0.78  | 0.46  | -0.55 | 0.34  | -0.39 | -0.18 | 0.09  |
| 149 | -1.15 | -1.02 | -0.96 | 0.78  | 1.46  | 0.68  | -0.42 | 0.42  | -0.56 | -0.37 | 0.03  |
| 150 | -1.14 | -1.48 | -1.27 | 0.40  | 1.82  | 0.73  | -0.39 | 0.25  | -0.22 | 0.14  | -0.17 |
| 151 | -1.18 | -1.25 | -0.62 | 0.36  | 1.69  | 0.56  | 0.05  | -0.17 | -0.23 | 0.36  | -0.19 |
| 152 | -1.45 | -1.45 | -0.54 | 0.16  | 0.95  | 0.16  | 0.42  | -0.10 | 0.25  | 0.01  | -0.05 |
| 153 | -1.79 | -1.66 | -0.03 | 0.02  | 0.14  | -0.14 | 0.77  | -0.19 | 0.23  | -0.04 | 0.22  |
| 154 | -1.97 | -1.97 | 0.15  | 0.04  | -0.73 | -0.06 | 0.66  | -0.04 | -0.11 | 0.20  | 0.23  |
| 155 | -1.91 | -3.03 | 0.49  | 0.12  | -0.98 | -0.22 | 0.51  | 0.13  | 0.13  | 0.04  | -0.0  |
| 156 | -2.37 | -3.72 | 0.89  | 0.89  | -1.57 | -0.50 | 0.66  | 0.30  | 0.10  | -0.03 | 0.15  |
| 157 | -2.72 | -4.49 | 0.92  | 1.24  | -1.47 | -0.98 | 0.54  | -0.03 | 0.07  | -0.34 | 0.16  |
| 158 | -2.72 | -5.15 | 0.66  | 2.06  | -1.04 | -1.38 | 0.25  | 0.19  | -0.08 | -0.38 | 0.02  |
| 159 | -2.63 | -5.71 | 0.17  | 2.54  | -0.23 | -1.14 | -0.55 | 0.09  | 0.08  | 0.04  | -0.09 |
| 160 | -2.77 | -5.97 | -0.50 | 2.99  | 0.15  | -0.55 | -0.74 | 0.17  | 0.08  | 0.43  | -0.17 |
| 161 | -2.77 | -6.31 | -0.28 | 3.24  | 0.11  | -0.64 | -0.52 | 0.29  | 0.23  | 0.05  | 0.05  |
| 162 | -2.90 | -6.41 | -0.23 | 3.91  | 0.33  | -0.81 | -0.09 | 0.33  | 0.42  | -0.45 | 0.26  |
| 163 | -3.01 | -6.35 | -0.02 | 4.25  | 0.18  | -0.92 | 0.23  | 0.49  | 0.25  | -0.55 | 0.12  |
| 164 | -3.21 | -6.00 | -0.47 | 4.09  | 0.02  | -0.54 | 0.16  | 0.42  | 0.06  | -0.12 | -0.16 |
| 165 | -3.72 | -4.70 | -0.42 | 3.82  | -0.29 | 0.14  | 0.38  | 0.31  | -0.03 | -0.22 | -0.29 |
| 166 | -4.38 | -3.59 | -1.16 | 3.90  | -0.51 | 0.42  | 0.36  | 0.04  | -0.09 | -0.01 | -0.23 |
| 167 | -5.07 | -2.82 | -2.00 | 3.23  | -1.46 | 0.43  | 0.43  | -0.35 | 0.02  | 0.09  | -0.08 |
| 168 | -5.34 | -2.11 | -2.82 | 2.96  | -2.36 | 0.55  | 0.01  | 0.01  | 0.09  | 0.37  | -0.09 |
| 169 | -5.78 | -2.29 | -3.10 | 2.48  | -2.04 | 1.19  | 0.10  | 0.69  | -0.07 | 0.07  | -0.24 |





Table D.1. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 170 | -5.27 | -3.06 | -2.58 | 1.77  | -1.48 | 1.50  | 0.02  | 0.81  | -0.16 | -0.10 | -0.29 |
| 171 | -5.69 | -1.83 | -1.99 | 1.23  | -0.63 | 1.37  | -0.19 | 0.56  | -0.39 | 0.02  | -0.04 |
| 172 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 173 | -6.17 | -0.30 | -1.27 | 0.56  | 0.01  | 0.36  | 0.36  | 0.32  | -0.08 | -0.02 | -0.19 |
| 174 | -6.38 | 0.01  | -1.81 | 0.37  | 0.08  | -0.15 | 0.58  | 0.07  | 0.02  | -0.30 | -0.09 |
| 175 | -6.78 | -0.13 | -2.05 | 0.56  | 0.22  | -0.37 | 0.69  | -0.20 | 0.18  | -0.26 | 0.15  |
| 176 | -6.26 | -0.20 | -1.76 | 0.57  | 0.47  | -1.29 | 0.70  | -0.33 | 0.12  | -0.08 | 0.03  |
| 177 | -6.38 | -0.63 | -1.25 | 0.64  | 0.47  | -1.94 | 0.88  | 0.09  | -0.12 | 0.20  | -0.04 |
| 178 | -6.08 | -0.39 | -1.76 | 0.67  | 0.20  | -2.10 | 0.88  | 0.37  | 0.03  | 0.0   | -0.20 |
| 179 | -5.93 | 0.14  | -2.35 | 1.25  | 0.30  | -2.28 | 0.82  | 0.43  | 0.06  | -0.20 | -0.36 |
| 180 | -5.52 | -0.12 | -3.24 | 0.99  | 0.68  | -1.88 | 1.19  | 0.03  | 0.04  | 0.04  | -0.14 |
| 181 | -4.68 | -0.15 | -3.48 | 1.54  | 1.19  | -1.12 | 0.98  | -0.53 | -0.02 | 0.0   | 0.09  |
| 182 | -3.56 | -0.03 | -3.86 | 1.94  | 1.48  | -0.24 | 0.66  | -0.60 | 0.31  | 0.02  | 0.14  |
| 183 | -3.95 | -0.09 | -3.08 | 1.95  | 1.97  | 0.31  | 0.44  | -0.56 | 0.15  | 0.09  | 0.18  |
| 184 | -2.95 | -0.25 | -1.70 | 1.90  | 2.19  | 0.54  | 0.30  | -0.57 | 0.07  | 0.14  | -0.06 |
| 185 | -2.20 | -0.18 | -0.59 | 1.35  | 2.24  | 0.81  | 0.25  | 0.23  | -0.21 | 0.02  | -0.32 |
| 186 | -1.84 | -0.01 | -0.23 | 1.20  | 2.20  | 0.52  | -0.07 | 0.11  | 0.24  | -0.39 | 0.16  |
| 187 | -2.06 | -0.32 | -0.11 | 1.03  | 1.78  | 0.72  | -0.77 | 0.27  | -0.21 | 0.04  | -0.11 |
| 188 | -2.94 | -0.96 | -0.78 | 0.54  | 1.07  | 0.78  | -0.70 | 0.36  | 0.38  | 0.20  | -0.11 |
| 189 | -3.35 | -0.48 | -0.89 | 0.49  | 0.52  | 0.51  | 0.45  | -0.05 | 0.11  | 0.28  | -0.18 |
| 190 | -3.98 | -0.11 | -0.63 | 0.42  | 0.37  | 0.20  | 1.20  | 0.68  | -0.33 | 0.07  | -0.18 |
| 191 | -4.46 | 0.24  | -0.10 | 0.25  | 0.36  | -0.77 | 0.90  | 0.72  | 0.22  | 0.08  | 0.14  |
| 192 | -4.11 | 0.02  | 0.03  | -0.47 | 1.54  | -0.71 | 0.39  | 0.58  | 0.31  | -0.08 | -0.04 |
| 193 | -4.45 | -0.37 | 0.48  | -1.23 | 2.71  | -0.60 | 0.30  | 0.17  | 0.05  | -0.06 | 0.14  |
| 194 | -4.53 | -0.45 | 0.27  | -2.04 | 2.88  | 0.10  | 0.47  | 0.25  | -0.16 | -0.07 | -0.10 |
| 195 | -3.62 | -0.05 | 0.71  | -2.36 | 2.66  | 0.54  | 0.83  | 0.27  | -0.04 | -0.35 | 0.07  |
| 196 | -3.88 | 0.60  | 0.72  | -2.57 | 1.70  | 0.76  | 0.70  | 0.24  | 0.60  | -0.16 | -0.02 |
| 197 | -3.06 | 0.68  | 1.50  | -2.60 | 1.10  | 0.40  | 0.84  | -0.23 | 0.47  | 0.22  | -0.31 |
| 198 | -2.79 | 0.60  | 1.90  | -2.66 | 0.77  | -0.07 | 0.64  | -0.25 | -0.52 | 0.33  | 0.19  |
| 199 | -2.42 | -0.44 | 2.42  | -2.47 | -0.42 | -0.25 | -0.12 | -0.33 | -0.55 | -0.04 | 0.33  |
| 200 | -1.90 | -1.80 | 2.89  | -1.93 | -1.59 | -0.68 | -0.83 | -0.72 | 0.28  | 0.27  | -0.16 |
| 201 | -1.93 | -2.70 | 3.32  | -1.57 | -2.71 | -1.29 | -0.80 | 0.07  | 0.33  | 0.30  | 0.19  |
| 202 | -2.51 | -2.91 | 3.35  | -1.78 | -2.68 | -0.95 | -0.65 | 1.06  | -0.05 | -0.53 | 0.40  |
| 203 | -2.79 | -3.54 | 3.33  | -2.03 | -2.28 | -0.25 | -0.23 | 1.13  | -0.35 | -0.18 | -0.09 |
| 204 | -2.49 | -4.28 | 2.93  | -2.00 | -1.56 | 0.52  | 0.44  | 0.23  | -0.23 | 0.17  | -0.26 |



Table D.1. cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 205 | -2.89 | -4.50 | 2.78  | -1.65 | -0.78 | 1.13  | 0.34  | -0.51 | -0.31 | -0.28 | 0.18  |
| 206 | -3.05 | -4.61 | 2.78  | -0.87 | -0.40 | 0.59  | 0.21  | -0.46 | -0.49 | -0.01 | 0.18  |
| 207 | -3.28 | -4.08 | 2.64  | -0.85 | -0.27 | 0.17  | -0.25 | 0.40  | -0.42 | 0.09  | -0.23 |
| 208 | -3.66 | -3.44 | 1.94  | -1.38 | 0.18  | 0.20  | -0.10 | 0.37  | 0.04  | -0.11 | -0.17 |
| 209 | -4.24 | -3.58 | 1.72  | -1.46 | 0.92  | 0.53  | 0.74  | -0.15 | -0.15 | -0.28 | -0.03 |
| 210 | -4.35 | -3.84 | 1.40  | -0.86 | 1.40  | 0.20  | 1.10  | -0.31 | -0.44 | -0.27 | 0.07  |
| 211 | -4.47 | -3.47 | 1.11  | -0.30 | 1.50  | -0.16 | 1.00  | -0.01 | -0.25 | 0.11  | -0.11 |
| 212 | -4.07 | -3.42 | 0.62  | 0.14  | 1.25  | -0.53 | 0.66  | 0.18  | -0.28 | 0.30  | -0.10 |
| 213 | -3.55 | -2.89 | 0.29  | -0.01 | 0.90  | -0.14 | 0.17  | 0.16  | -0.18 | 0.13  | 0.17  |
| 214 | -3.64 | -2.45 | -0.28 | 0.09  | 0.20  | 0.52  | -0.29 | -0.04 | -0.04 | 0.01  | -0.09 |
| 215 | -3.41 | -1.92 | -0.44 | 0.58  | -0.13 | 0.82  | -0.21 | 0.07  | -0.19 | 0.19  | -0.12 |
| 216 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 217 | -3.09 | -1.68 | -0.98 | 1.94  | -0.46 | 1.21  | -0.35 | 0.59  | -0.54 | -0.06 | 0.01  |
| 218 | -3.16 | -1.25 | -1.51 | 2.75  | -0.50 | 1.13  | -0.91 | 0.82  | 0.09  | -0.04 | -0.07 |
| 219 | -3.49 | -0.56 | -2.14 | 3.17  | -0.77 | 0.95  | -0.95 | 0.94  | 0.22  | -0.17 | 0.33  |
| 220 | -3.50 | 0.36  | -2.94 | 3.34  | -0.42 | 0.57  | -0.82 | 0.69  | 0.19  | 0.17  | 0.22  |
| 221 | -3.82 | 0.83  | -3.36 | 3.32  | -0.05 | 0.01  | -1.10 | 0.72  | 0.0   | 0.45  | -0.05 |
| 222 | -2.98 | 1.79  | -3.99 | 2.77  | 0.19  | 0.13  | -1.13 | 0.58  | 0.03  | 0.32  | -0.03 |
| 223 | -3.05 | 2.36  | -3.96 | 1.96  | 0.39  | 0.61  | -0.80 | -0.12 | -0.01 | 0.22  | 0.0   |
| 224 | -3.13 | 2.73  | -3.55 | 1.15  | 0.59  | 0.70  | -0.09 | -0.04 | -0.39 | -0.01 | -0.02 |
| 225 | -4.05 | 2.88  | -2.66 | 0.26  | 0.73  | 0.48  | 0.71  | 0.16  | -0.59 | -0.24 | -0.17 |
| 226 | -4.28 | 2.71  | -1.61 | -0.43 | 0.82  | 0.68  | 1.07  | 0.62  | -0.47 | -0.10 | -0.14 |
| 227 | -4.74 | 1.92  | -0.90 | -0.43 | 0.30  | 1.14  | 1.47  | 0.68  | -0.11 | -0.04 | 0.07  |
| 228 | -6.65 | 1.32  | -0.86 | -0.20 | 0.37  | 1.26  | 1.42  | 0.54  | 0.02  | 0.12  | 0.11  |
| 229 | -7.32 | 1.27  | 0.0   | 0.15  | 0.36  | 0.68  | 0.67  | 0.05  | 0.04  | 0.10  | 0.06  |
| 230 | -7.55 | 1.32  | 0.58  | 0.08  | -0.17 | 0.22  | 0.04  | -0.47 | 0.09  | -0.16 | -0.29 |
| 231 | -7.57 | 1.76  | 0.32  | 0.23  | -0.74 | 0.26  | -0.52 | -0.60 | -0.07 | 0.15  | -0.28 |
| 232 | -7.25 | 1.97  | -0.65 | 0.03  | -1.10 | 0.18  | -0.62 | 0.20  | -0.11 | 0.04  | -0.10 |
| 233 | -6.58 | 1.92  | -1.48 | -0.19 | -1.06 | 0.48  | -0.70 | 0.96  | 0.00  | -0.20 | -0.08 |
| 234 | -6.04 | 1.16  | -2.74 | -0.75 | -0.03 | 1.05  | -0.71 | 0.30  | -0.01 | 0.13  | 0.00  |
| 235 | -5.38 | 0.88  | -2.77 | -0.70 | 0.41  | 0.98  | -0.29 | 0.04  | -0.21 | 0.13  | 0.24  |
| 236 | -5.44 | 0.23  | -2.76 | -0.74 | -0.21 | 0.70  | 0.20  | 0.03  | -0.15 | 0.16  | -0.25 |
| 237 | -5.46 | -0.11 | -2.08 | -0.28 | -0.36 | 0.73  | 0.39  | -0.26 | -0.31 | 0.26  | -0.19 |
| 238 | -4.90 | -1.21 | -1.81 | -0.03 | -0.10 | 0.29  | 0.39  | -0.26 | -0.27 | 0.24  | -0.12 |
| 239 | -4.30 | -1.82 | -1.46 | 0.46  | 0.77  | 0.30  | 0.01  | -0.07 | -0.42 | 0.20  | 0.04  |
| 240 | -3.24 | -2.18 | -1.62 | 0.53  | 1.41  | 0.13  | -0.04 | -0.05 | -0.31 | -0.16 | 0.04  |



Table D.2. Values of BAMPL for NUMB = 240

| ROW | Wave Number |       |       |       |       |       |       |       |       |       |       |
|-----|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|     | 1           | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    |
| 1   | 0.90        | 3.59  | -3.33 | -1.96 | 2.03  | 0.65  | -0.66 | 0.30  | -0.17 | -0.18 | 0.11  |
| 2   | 0.96        | 1.94  | -2.52 | -1.93 | 1.67  | -0.29 | -0.74 | 0.47  | 0.38  | -0.22 | 0.23  |
| 3   | 1.23        | 0.99  | -0.53 | -1.56 | 1.00  | -0.47 | -0.34 | 0.21  | -0.04 | -0.12 | 0.04  |
| 4   | 0.98        | 1.25  | 0.53  | -1.47 | 0.38  | -0.14 | -0.10 | -0.48 | -0.52 | 0.11  | 0.07  |
| 5   | 0.73        | 1.78  | 1.45  | -1.65 | 0.34  | -0.15 | -0.04 | -0.42 | -0.43 | 0.33  | -0.01 |
| 6   | -0.10       | 2.40  | 2.11  | -1.75 | -0.14 | -0.23 | 0.76  | -0.20 | -0.08 | 0.10  | -0.07 |
| 7   | -0.72       | 3.40  | 2.14  | -1.24 | -1.22 | 0.35  | 0.86  | -0.11 | 0.29  | -0.32 | -0.0  |
| 8   | -1.53       | 4.11  | 2.25  | -1.04 | -2.08 | 1.12  | 0.30  | 0.18  | 0.37  | -0.10 | 0.26  |
| 9   | 99.99       | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 10  | 99.99       | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 11  | -2.51       | 2.85  | 3.47  | -1.66 | -0.37 | 0.42  | -0.57 | -0.44 | 0.53  | 0.08  | 0.13  |
| 12  | -3.08       | 2.18  | 3.80  | -1.43 | 0.63  | 0.0   | -0.71 | -0.59 | 0.47  | 0.06  | 0.02  |
| 13  | -3.14       | 2.29  | 3.96  | -1.04 | 1.12  | -0.46 | -0.88 | -0.45 | -0.17 | -0.20 | 0.25  |
| 14  | -3.43       | 3.23  | 3.89  | -0.65 | 1.38  | -0.59 | -1.24 | -0.18 | -0.27 | 0.04  | 0.12  |
| 15  | -3.52       | 4.18  | 3.72  | -0.70 | 1.24  | -1.00 | -0.94 | 0.26  | -0.09 | 0.10  | -0.10 |
| 16  | -3.93       | 4.94  | 3.25  | -0.42 | 1.07  | -1.30 | 0.21  | 0.16  | 0.23  | -0.22 | 0.06  |
| 17  | -4.05       | 5.59  | 2.44  | -0.11 | 0.95  | -1.10 | 0.92  | -0.36 | -0.13 | -0.14 | 0.05  |
| 18  | -4.98       | 5.93  | 1.50  | 0.85  | 0.42  | -0.85 | 1.14  | -0.68 | -0.03 | 0.15  | -0.08 |
| 19  | -4.99       | 5.83  | 0.61  | 1.28  | -0.47 | -0.04 | 0.21  | -0.80 | 0.18  | -0.11 | -0.07 |
| 20  | -5.41       | 5.20  | -0.13 | 1.76  | -0.85 | 1.00  | -0.88 | -0.15 | -0.13 | 0.01  | -0.26 |
| 21  | -6.20       | 5.50  | -1.01 | 1.70  | -1.05 | 1.30  | -1.20 | 0.31  | -0.81 | 0.24  | -0.32 |
| 22  | -7.05       | 6.50  | -2.00 | 1.67  | -0.90 | 1.51  | -0.66 | -0.07 | -0.52 | -0.13 | -0.27 |
| 23  | -7.32       | 6.61  | -2.89 | 1.64  | -0.48 | 1.68  | -0.36 | -0.29 | 0.18  | -0.34 | 0.29  |
| 24  | -7.94       | 7.02  | -3.17 | 1.72  | 0.49  | 1.08  | -0.24 | -0.16 | 0.47  | -0.11 | 0.04  |
| 25  | -7.46       | 7.17  | -2.28 | 0.95  | 0.52  | 0.60  | 0.15  | 0.04  | 0.40  | 0.03  | -0.18 |
| 26  | 99.99       | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 27  | -7.45       | 7.31  | -1.46 | 1.29  | -0.61 | 0.70  | 0.47  | -0.78 | 0.71  | -0.13 | -0.01 |
| 28  | -7.21       | 8.08  | -1.91 | 1.17  | -0.89 | 0.65  | -0.31 | -0.37 | 0.64  | -0.37 | 0.02  |
| 29  | -6.95       | 8.27  | -2.69 | 0.68  | -1.24 | 1.27  | -0.95 | -0.23 | -0.12 | 0.33  | 0.16  |





Table D.2. Cont'

|    |       |       |       |       |       |       |       |       |       |       |       |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 30 | -7.25 | 8.09  | -2.83 | 0.70  | -1.13 | 1.09  | -0.77 | -0.37 | -0.43 | 0.29  | -0.37 |
| 31 | -6.83 | 7.48  | -2.29 | 0.27  | -1.16 | 0.24  | -0.06 | 0.15  | -0.53 | -0.10 | -0.26 |
| 32 | -6.40 | 6.77  | -1.49 | 0.05  | -0.76 | -0.05 | -0.04 | 0.28  | -0.17 | -0.21 | -0.32 |
| 33 | -6.08 | 6.41  | -1.13 | -0.15 | 0.12  | -0.53 | -0.12 | 0.38  | 0.05  | 0.09  | -0.11 |
| 34 | -5.37 | 6.93  | -0.65 | -0.32 | 0.31  | -0.49 | 0.46  | -0.02 | -0.21 | 0.09  | 0.08  |
| 35 | -4.37 | 7.05  | -0.11 | -0.91 | 0.35  | -0.33 | 0.76  | -0.66 | -0.12 | 0.02  | 0.03  |
| 36 | -3.80 | 6.89  | -0.15 | -0.96 | 0.11  | 0.46  | 0.69  | -0.87 | 0.14  | -0.04 | 0.17  |
| 37 | -2.75 | 6.92  | -0.61 | -1.31 | 0.40  | 1.23  | 0.18  | -0.65 | 0.35  | 0.08  | 0.17  |
| 38 | -2.48 | 6.48  | -1.22 | -1.06 | 0.43  | 1.42  | -0.24 | -0.35 | 0.33  | 0.05  | -0.11 |
| 39 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 40 | -3.03 | 5.31  | -2.31 | -0.36 | 0.10  | 1.34  | -0.63 | 0.33  | -0.58 | -0.13 | -0.24 |
| 41 | -3.31 | 4.94  | -2.21 | -0.48 | 0.12  | 0.80  | -0.03 | 0.03  | -1.02 | 0.23  | -0.0  |
| 42 | -3.51 | 4.42  | -1.81 | -1.29 | 0.84  | 0.16  | 0.24  | -0.43 | -0.61 | 0.48  | 0.01  |
| 43 | -3.17 | 4.22  | -1.69 | -1.74 | 1.37  | -0.38 | 0.40  | -0.73 | 0.09  | 0.26  | -0.16 |
| 44 | -3.34 | 3.82  | -2.01 | -1.99 | 1.43  | -0.92 | 0.47  | -0.39 | 0.44  | -0.23 | -0.29 |
| 45 | -3.00 | 3.83  | -2.39 | -1.55 | 1.26  | -0.87 | 0.52  | -0.34 | 0.35  | -0.63 | 0.09  |
| 46 | -2.20 | 3.11  | -2.25 | -1.53 | 0.86  | -0.23 | 0.21  | -0.58 | 0.17  | -0.47 | 0.27  |
| 47 | -1.02 | 2.99  | -1.99 | -1.47 | 0.12  | 0.30  | 0.10  | -0.77 | -0.39 | -0.34 | 0.17  |
| 48 | -0.71 | 2.31  | -1.62 | -0.93 | -0.20 | 0.45  | -0.13 | -0.34 | -0.41 | -0.32 | -0.14 |
| 49 | -0.19 | 1.35  | -0.90 | -0.18 | -0.83 | 0.44  | -0.31 | -0.31 | 0.30  | -0.28 | -0.21 |
| 50 | -0.92 | 0.59  | -0.68 | 0.22  | -0.84 | 0.65  | -0.15 | -0.48 | 0.48  | -0.22 | -0.17 |
| 51 | -1.42 | -0.53 | -0.28 | 0.67  | -0.40 | -0.12 | 0.05  | -0.26 | 0.28  | 0.13  | -0.11 |
| 52 | -1.98 | -1.17 | 0.39  | 1.24  | -0.23 | -0.03 | 0.16  | -0.33 | 0.46  | -0.28 | 0.02  |
| 53 | -2.43 | -1.92 | 1.42  | 1.09  | 0.99  | -0.41 | 0.28  | -0.50 | 0.05  | 0.0   | 0.12  |
| 54 | -2.00 | -2.93 | 2.03  | 0.70  | 1.46  | -0.19 | -0.24 | -0.69 | -0.33 | 0.38  | -0.19 |
| 55 | -0.92 | -3.73 | 2.28  | 0.46  | 1.79  | 0.16  | -0.58 | -0.60 | -0.29 | 0.38  | 0.11  |
| 56 | -0.52 | -4.93 | 2.79  | 0.03  | 1.65  | -0.15 | -0.96 | -0.18 | 0.11  | -0.06 | 0.19  |
| 57 | 0.26  | -5.64 | 3.17  | 0.36  | 1.46  | -0.65 | -0.79 | -0.24 | 0.58  | -0.31 | 0.18  |
| 58 | 0.42  | -5.66 | 2.92  | -0.0  | 1.13  | -0.84 | -0.86 | -0.31 | 0.55  | -0.33 | -0.07 |
| 59 | 0.55  | -5.47 | 2.67  | -0.68 | 1.17  | -0.97 | -0.27 | -0.39 | 0.29  | -0.16 | -0.17 |
| 60 | 0.18  | -4.62 | 1.89  | -0.67 | 2.12  | -1.23 | -0.01 | -0.04 | 0.27  | -0.32 | -0.40 |
| 61 | -0.27 | -3.24 | 0.70  | -1.20 | 1.99  | -0.96 | 0.37  | -0.20 | 0.54  | -0.19 | -0.13 |
| 62 | -1.67 | -1.66 | -0.15 | -0.73 | 1.53  | -0.17 | 0.71  | -0.43 | 0.44  | -0.13 | -0.07 |
| 63 | -2.68 | -0.27 | -0.18 | -0.46 | 0.84  | 0.27  | 0.99  | -0.44 | 0.11  | 0.23  | 0.0   |
| 64 | -3.74 | 1.20  | -0.56 | 0.12  | 0.35  | 0.25  | 0.77  | -0.07 | -0.06 | 0.23  | 0.0   |





Table D.2. Cont'

|    |       |       |       |       |       |       |       |       |       |       |       |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 65 | -4.80 | 2.86  | -0.65 | 0.56  | -0.0  | 0.30  | 0.35  | 0.46  | 0.09  | 0.01  | 0.01  |
| 66 | -5.77 | 4.10  | -1.35 | 0.61  | -0.32 | 1.04  | 0.09  | 0.44  | -0.03 | 0.03  | -0.04 |
| 67 | -6.08 | 5.67  | -1.90 | 1.05  | -0.51 | 1.69  | -0.14 | 0.33  | -0.01 | 0.24  | 0.08  |
| 68 | -5.87 | 6.62  | -2.59 | 0.79  | -0.44 | 1.56  | -0.07 | 0.04  | 0.24  | -0.10 | 0.17  |
| 69 | -4.77 | 7.62  | -3.04 | -0.29 | 0.02  | 1.69  | 0.04  | 0.38  | 0.05  | -0.30 | 0.05  |
| 70 | -4.54 | 7.31  | -3.12 | -0.60 | 0.41  | 2.03  | -0.02 | 0.40  | -0.30 | -0.02 | 0.03  |
| 71 | -3.68 | 7.04  | -3.12 | -1.43 | 0.99  | 1.76  | 0.48  | -0.36 | -0.02 | 0.15  | 0.28  |
| 72 | -2.37 | 6.28  | -2.73 | -2.03 | 1.73  | 0.64  | 0.42  | -0.41 | 0.16  | 0.62  | -0.0  |
| 73 | -0.90 | 5.77  | -1.83 | -2.35 | 1.47  | 0.45  | 0.24  | -0.18 | 0.66  | 0.01  | -0.08 |
| 74 | -0.21 | 5.25  | -1.66 | -2.38 | 0.73  | 0.33  | -0.11 | 0.17  | 0.38  | -0.32 | -0.13 |
| 75 | 0.36  | 5.42  | -1.65 | -2.20 | -0.18 | 0.69  | -0.36 | 0.39  | -0.16 | -0.45 | 0.25  |
| 76 | -0.09 | 5.76  | -1.80 | -1.64 | -0.95 | 1.21  | -0.30 | 0.38  | -0.38 | -0.14 | 0.29  |
| 77 | 0.70  | 4.88  | -1.49 | -1.32 | -0.92 | 0.75  | 0.25  | 0.22  | -0.36 | -0.13 | 0.27  |
| 78 | 1.08  | 3.46  | -0.84 | -1.90 | -0.23 | -0.24 | 0.37  | -0.27 | -0.06 | -0.18 | 0.03  |
| 79 | 0.88  | 2.46  | 0.12  | -1.81 | 0.71  | -0.50 | 0.60  | -0.23 | 0.28  | 0.04  | -0.31 |
| 80 | 0.57  | 1.59  | 1.10  | -1.53 | 1.49  | -0.26 | 0.96  | -0.07 | 0.58  | 0.42  | -0.36 |
| 81 | 0.82  | 0.71  | 2.22  | -1.84 | 1.53  | -0.13 | 0.99  | 0.14  | 0.25  | 0.53  | -0.14 |
| 82 | 0.52  | 0.22  | 3.18  | -2.17 | 1.18  | -0.30 | 0.48  | 0.10  | 0.04  | 0.34  | 0.34  |
| 83 | 0.24  | -0.35 | 3.24  | -2.74 | 1.17  | -0.64 | -0.02 | -0.03 | 0.0   | 0.10  | 0.25  |
| 84 | -0.52 | -0.54 | 2.76  | -3.34 | 1.62  | -0.56 | 0.04  | -0.32 | 0.22  | -0.03 | -0.10 |
| 85 | -0.94 | -0.85 | 2.26  | -3.57 | 1.51  | -0.30 | 0.28  | -0.43 | 0.31  | 0.06  | -0.12 |
| 86 | -1.07 | -0.42 | 2.52  | -3.70 | 0.86  | -0.99 | 0.42  | -0.50 | 0.39  | 0.01  | 0.28  |
| 87 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 88 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 89 | -1.74 | 1.09  | 0.25  | -2.37 | 1.84  | 0.50  | -0.15 | -0.46 | 0.14  | -0.25 | -0.09 |
| 90 | -1.77 | 1.98  | -1.00 | -2.58 | 1.65  | 1.07  | -0.38 | -0.27 | 0.56  | 0.35  | 0.07  |
| 91 | -1.39 | 2.42  | -1.31 | -2.88 | 1.67  | 1.15  | -0.79 | -0.04 | 0.35  | 0.23  | -0.04 |
| 92 | -1.00 | 2.51  | -1.09 | -2.95 | 1.13  | 1.00  | -1.25 | 0.46  | 0.24  | 0.15  | 0.05  |
| 93 | -0.33 | 2.74  | -0.61 | -1.78 | 1.20  | 1.32  | -1.37 | 0.32  | 0.12  | 0.07  | 0.20  |
| 94 | -1.03 | 2.06  | -1.78 | 0.23  | 1.01  | 1.63  | -1.03 | 0.04  | 0.11  | 0.09  | 0.16  |
| 95 | -1.84 | 1.41  | -3.58 | 1.39  | 1.30  | 1.27  | -0.66 | -0.16 | 0.23  | -0.06 | 0.30  |
| 96 | -2.10 | 0.99  | -4.36 | 1.29  | 1.05  | 0.15  | -0.52 | -0.0  | 0.32  | 0.16  | -0.04 |
| 97 | -1.55 | 0.89  | -4.11 | 0.82  | 1.10  | -0.27 | -0.09 | 0.39  | 0.47  | -0.24 | 0.25  |
| 98 | -1.61 | 1.37  | -3.66 | 0.12  | 0.65  | -0.22 | 0.49  | -0.13 | 0.43  | -0.43 | 0.28  |
| 99 | -1.02 | 2.11  | -2.85 | -0.70 | 0.47  | 0.20  | 0.13  | -0.34 | 0.68  | -0.11 | 0.02  |



Table D.2. Cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 100 | -1.52 | 2.10  | -2.18 | -0.63 | 0.85  | 0.39  | -0.45 | -0.39 | 0.79  | -0.09 | -0.06 |
| 101 | -1.70 | 1.86  | -1.43 | -0.47 | 1.27  | 0.44  | -0.28 | -0.48 | 0.70  | -0.23 | 0.23  |
| 102 | -2.03 | 1.57  | -1.31 | -0.58 | 1.57  | -0.14 | -0.30 | -0.89 | 0.77  | -0.16 | 0.0   |
| 103 | -2.01 | 1.44  | -1.93 | -0.86 | 1.31  | -0.46 | -0.18 | -0.69 | 0.59  | -0.37 | -0.09 |
| 104 | -1.97 | 0.71  | -2.55 | -0.68 | 1.01  | 0.12  | -0.22 | -0.24 | -0.21 | 0.05  | 0.09  |
| 105 | -1.26 | 0.44  | -2.84 | -0.54 | 1.03  | 0.47  | 0.24  | -0.05 | -0.48 | 0.60  | 0.04  |
| 106 | -1.23 | -0.11 | -3.21 | -0.76 | 0.43  | 0.57  | 0.34  | 0.41  | -0.58 | 0.35  | -0.22 |
| 107 | -0.88 | 0.22  | -3.23 | -1.24 | -0.32 | 0.28  | 0.23  | 0.41  | -0.53 | 0.26  | 0.01  |
| 108 | -1.50 | 0.72  | -3.27 | -1.57 | -0.53 | 0.46  | -0.06 | 0.10  | -0.20 | 0.06  | 0.20  |
| 109 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 110 | -1.30 | 1.81  | -3.33 | -2.56 | -0.20 | 0.63  | -0.11 | 0.12  | -0.06 | -0.42 | 0.02  |
| 111 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 112 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 113 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 114 | -0.22 | 1.80  | 0.12  | -3.20 | 1.84  | 0.68  | -0.30 | -0.01 | 0.07  | 0.01  | 0.02  |
| 115 | -0.17 | 1.69  | 0.94  | -2.50 | 1.84  | 0.87  | -0.18 | -0.18 | 0.36  | -0.19 | 0.12  |
| 116 | -0.68 | 1.67  | 1.27  | -1.62 | 1.93  | 1.08  | 0.03  | -0.25 | 0.54  | -0.29 | 0.04  |
| 117 | -0.79 | 2.00  | 0.92  | -1.07 | 1.52  | 0.77  | 0.14  | -0.26 | 0.46  | -0.05 | -0.12 |
| 118 | -0.84 | 2.39  | 0.98  | -0.90 | 1.67  | 0.21  | 0.42  | -0.44 | -0.07 | 0.04  | -0.27 |
| 119 | -0.52 | 2.90  | 0.77  | -0.64 | 1.65  | 0.36  | 0.16  | -0.49 | -0.19 | -0.24 | 0.17  |
| 120 | -0.48 | 2.78  | 0.99  | -0.80 | 1.53  | 0.63  | -0.08 | -0.49 | -0.50 | -0.0  | -0.02 |
| 121 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 122 | -0.77 | 2.42  | 0.45  | -0.73 | 1.31  | -0.40 | 0.65  | -0.65 | -0.02 | -0.09 | -0.14 |
| 123 | -1.45 | 1.97  | -0.58 | -0.84 | 0.70  | -0.59 | 0.72  | -0.33 | 0.29  | -0.03 | -0.13 |
| 124 | -2.24 | 1.75  | -2.22 | -1.26 | 0.07  | -0.68 | 0.54  | -0.26 | -0.01 | 0.01  | -0.21 |
| 125 | -2.39 | 1.13  | -3.13 | -1.67 | -0.35 | -0.28 | 0.50  | 0.17  | -0.25 | 0.19  | -0.07 |
| 126 | -2.66 | 0.82  | -3.42 | -1.92 | -0.20 | 0.13  | 0.26  | -0.14 | -0.37 | 0.27  | -0.10 |
| 127 | -2.69 | 0.24  | -3.42 | -1.93 | 0.45  | 1.03  | 0.14  | -0.42 | 0.22  | 0.09  | -0.03 |
| 128 | -2.96 | -0.08 | -3.35 | -1.61 | 1.30  | 1.45  | 0.13  | -0.44 | 0.52  | -0.11 | -0.11 |
| 129 | -2.62 | 0.22  | -2.69 | -1.45 | 1.61  | 1.20  | 0.23  | -0.26 | 0.50  | -0.48 | -0.26 |
| 130 | -2.61 | 0.83  | -2.43 | -1.56 | 1.51  | 1.11  | 0.07  | -0.16 | -0.27 | -0.20 | -0.19 |
| 131 | -2.27 | 1.13  | -2.52 | -1.59 | 1.28  | 1.06  | -0.28 | 0.01  | -0.52 | 0.09  | -0.26 |
| 132 | -2.36 | 0.85  | -3.37 | -1.65 | 0.92  | 0.46  | -0.64 | -0.23 | -0.05 | -0.33 | 0.19  |
| 133 | -1.70 | 0.67  | -3.46 | -1.75 | 1.03  | -0.28 | -0.40 | -0.31 | 0.30  | -0.73 | 0.21  |
| 134 | -1.25 | 0.89  | -3.37 | -1.51 | 0.97  | -0.54 | -0.34 | -0.45 | 0.18  | -0.36 | 0.06  |



Table D.2. Cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 135 | -0.42 | 1.46  | -2.97 | -0.67 | 1.03  | -0.09 | -0.93 | 0.06  | -0.0  | 0.01  | -0.20 |
| 136 | -0.50 | 1.07  | -3.30 | -0.37 | 1.18  | -0.04 | -0.97 | -0.37 | 0.24  | -0.04 | 0.15  |
| 137 | 0.38  | 1.35  | -3.31 | 0.56  | 1.24  | -0.17 | -0.91 | -0.69 | 0.46  | -0.02 | 0.12  |
| 138 | 0.33  | 1.13  | -3.40 | 0.73  | 1.45  | 0.43  | -0.91 | -0.30 | 0.06  | 0.31  | -0.31 |
| 139 | 0.42  | 1.09  | -3.55 | 1.00  | 1.32  | 1.34  | -0.83 | -0.29 | -0.54 | 0.23  | -0.14 |
| 140 | -0.15 | 1.20  | -3.61 | 1.35  | 1.11  | 1.93  | -0.61 | -0.27 | -0.51 | 0.02  | 0.07  |
| 141 | -0.46 | 1.28  | -3.31 | 1.64  | 1.15  | 1.41  | -0.03 | -0.23 | -0.27 | -0.13 | -0.14 |
| 142 | -1.29 | 1.04  | -3.55 | 1.51  | 0.83  | 0.92  | 0.37  | -0.17 | -0.24 | 0.03  | -0.06 |
| 143 | -0.96 | 1.26  | -3.14 | 1.54  | 0.58  | 0.07  | 0.89  | -0.22 | -0.19 | 0.28  | -0.09 |
| 144 | -1.09 | 0.51  | -2.30 | 1.55  | 0.52  | -0.53 | 1.25  | 0.18  | -0.29 | 0.12  | -0.27 |
| 145 | -0.87 | 0.13  | -2.06 | 1.94  | 0.67  | -0.47 | 1.08  | -0.16 | -0.21 | -0.01 | 0.14  |
| 146 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 147 | -0.44 | -0.60 | -2.40 | 2.01  | 0.81  | -0.44 | -0.30 | -0.31 | 0.38  | -0.01 | -0.01 |
| 148 | -1.03 | -0.69 | -2.50 | 1.79  | 0.92  | -0.47 | -0.60 | -0.26 | 0.07  | 0.34  | -0.11 |
| 149 | -0.86 | -0.53 | -2.26 | 1.43  | 1.44  | -0.41 | -0.32 | 0.14  | 0.01  | -0.19 | 0.22  |
| 150 | -0.78 | -0.29 | -3.20 | 0.76  | 1.72  | 0.12  | -0.49 | 0.24  | 0.0   | -0.23 | 0.10  |
| 151 | -0.01 | 0.21  | -3.75 | 0.05  | 2.36  | 0.51  | -0.81 | 0.19  | -0.01 | 0.12  | -0.17 |
| 152 | -0.28 | 0.30  | -3.79 | -0.41 | 2.84  | 0.64  | -0.96 | -0.16 | -0.11 | 0.34  | 0.01  |
| 153 | -0.09 | 0.47  | -4.00 | -0.70 | 2.68  | 0.45  | -0.56 | -0.34 | 0.07  | -0.12 | 0.07  |
| 154 | -0.73 | 1.37  | -3.82 | -1.64 | 1.99  | 0.45  | 0.02  | -0.46 | 0.08  | -0.20 | 0.08  |
| 155 | -0.56 | 2.35  | -3.32 | -1.66 | 0.99  | 0.57  | 0.03  | -0.57 | -0.18 | -0.07 | -0.15 |
| 156 | -1.51 | 2.83  | -2.67 | -1.71 | 0.24  | 0.38  | 0.02  | -0.45 | 0.02  | -0.10 | -0.22 |
| 157 | -1.89 | 3.74  | -1.72 | -1.51 | -0.51 | 0.19  | 0.32  | -0.52 | 0.09  | 0.01  | 0.05  |
| 158 | -3.18 | 3.75  | -1.03 | -1.02 | -0.89 | -0.37 | 0.63  | -0.30 | 0.11  | -0.19 | -0.01 |
| 159 | -3.68 | 4.32  | -0.75 | -0.35 | -1.12 | -0.70 | 0.30  | -0.36 | 0.06  | -0.29 | 0.0   |
| 160 | -3.80 | 4.44  | -1.44 | -0.09 | -0.29 | -0.64 | -0.29 | -0.52 | 0.07  | 0.08  | -0.01 |
| 161 | -3.25 | 4.50  | -1.95 | 0.17  | 0.42  | 0.06  | -0.76 | -0.59 | -0.35 | 0.33  | -0.21 |
| 162 | -3.15 | 4.44  | -2.21 | 0.04  | 0.92  | 0.34  | -0.67 | -0.29 | -0.28 | 0.21  | -0.12 |
| 163 | -2.27 | 4.22  | -1.79 | 0.14  | 1.21  | -0.14 | -0.04 | 0.18  | 0.13  | -0.43 | 0.22  |
| 164 | -1.95 | 3.69  | -0.89 | 0.29  | 1.62  | -0.83 | 0.19  | 0.70  | 0.38  | -0.19 | 0.08  |
| 165 | -1.37 | 3.75  | -0.36 | 0.67  | 1.58  | -1.06 | -0.32 | 0.59  | 0.26  | 0.09  | -0.02 |
| 166 | -1.67 | 3.65  | -0.05 | -0.11 | 1.86  | -1.25 | -0.30 | 0.46  | 0.17  | 0.25  | -0.02 |
| 167 | -1.52 | 4.07  | -0.25 | -0.24 | 1.89  | -0.95 | -0.08 | -0.03 | 0.13  | -0.02 | 0.14  |
| 168 | -2.28 | 4.83  | -0.65 | -0.49 | 1.01  | -1.08 | 0.13  | -0.77 | 0.06  | -0.03 | 0.14  |
| 169 | -2.06 | 5.10  | -1.19 | -0.24 | 0.03  | -1.07 | 0.18  | -0.48 | 0.32  | 0.40  | 0.29  |





Table D.2. Cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 170 | -2.08 | 4.64  | -1.64 | 0.35  | -1.10 | -0.38 | 0.18  | -0.09 | 0.48  | 0.16  | -0.03 |
| 171 | -1.57 | 3.51  | -1.90 | 0.30  | -1.18 | 0.42  | -0.01 | 0.26  | 0.37  | 0.02  | -0.18 |
| 172 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 173 | -1.85 | 1.96  | -1.46 | -0.27 | -0.93 | 0.83  | -0.67 | -0.01 | -0.42 | 0.30  | 0.25  |
| 174 | -2.10 | 1.23  | -0.90 | -0.59 | -0.84 | 0.92  | -0.38 | 0.42  | -0.16 | 0.26  | -0.17 |
| 175 | -1.48 | 1.23  | -0.82 | -0.30 | -0.79 | 1.47  | 0.03  | 0.51  | 0.07  | 0.07  | -0.04 |
| 176 | -1.63 | 1.17  | -0.85 | 0.15  | -0.91 | 1.62  | -0.31 | 0.01  | -0.09 | 0.14  | 0.17  |
| 177 | -0.93 | 1.06  | -0.72 | 0.45  | -1.21 | 0.91  | -0.55 | -0.40 | -0.21 | -0.01 | 0.01  |
| 178 | -1.37 | 0.42  | -0.63 | 0.20  | -1.18 | 0.34  | -0.40 | -0.39 | -0.30 | 0.13  | 0.04  |
| 179 | -0.69 | 0.36  | -1.14 | 0.31  | -1.13 | 0.15  | 0.10  | 0.29  | -0.05 | -0.02 | -0.03 |
| 180 | -1.02 | 0.17  | -1.36 | 0.78  | -0.48 | -0.30 | 0.51  | 0.60  | 0.0   | 0.21  | -0.30 |
| 181 | -1.54 | 0.76  | -1.94 | 1.57  | -0.53 | -0.89 | 0.74  | 0.56  | -0.34 | 0.24  | -0.31 |
| 182 | -2.13 | 0.65  | -2.15 | 2.38  | -0.38 | -1.05 | 0.61  | 0.10  | 0.03  | 0.10  | 0.12  |
| 183 | -1.96 | 0.35  | -2.19 | 3.05  | 0.04  | -0.65 | 0.75  | -0.04 | 0.01  | -0.14 | 0.15  |
| 184 | -2.63 | -0.60 | -2.54 | 3.12  | 0.43  | -0.12 | 0.51  | -0.57 | 0.14  | 0.14  | 0.49  |
| 185 | -1.88 | -1.05 | -2.85 | 3.25  | 0.75  | 0.35  | 0.61  | -0.60 | -0.13 | 0.47  | 0.04  |
| 186 | -0.97 | -1.28 | -2.71 | 3.00  | 0.83  | 0.73  | 0.98  | -0.11 | -0.13 | -0.07 | 0.08  |
| 187 | 0.65  | -1.19 | -2.55 | 2.77  | 1.37  | 0.64  | 0.60  | -0.35 | -0.04 | -0.35 | 0.12  |
| 188 | 1.33  | -1.53 | -2.63 | 2.15  | 0.85  | 0.93  | -0.76 | 0.09  | -0.35 | -0.33 | -0.06 |
| 189 | 2.63  | -1.60 | -2.83 | 2.13  | 0.29  | 1.01  | -1.40 | -0.35 | 0.45  | -0.11 | -0.07 |
| 190 | 1.78  | -1.91 | -3.43 | 1.64  | -0.25 | 1.44  | -0.55 | -0.38 | 0.11  | 0.33  | -0.29 |
| 191 | 1.64  | -1.42 | -3.11 | 1.97  | -1.06 | 0.80  | 0.13  | 0.04  | -0.36 | 0.23  | -0.06 |
| 192 | -0.02 | -0.96 | -2.92 | 2.06  | -1.67 | -0.02 | 0.39  | 0.40  | 0.09  | -0.0  | -0.08 |
| 193 | -1.38 | -1.10 | -3.20 | 2.33  | -1.20 | -0.45 | -0.10 | 0.38  | 0.29  | 0.21  | 0.07  |
| 194 | -2.92 | -1.07 | -3.51 | 1.92  | 0.23  | -0.67 | -0.49 | 0.36  | 0.34  | 0.22  | 0.03  |
| 195 | -3.23 | -0.76 | -4.28 | 1.84  | 1.30  | -0.52 | -0.27 | 0.12  | -0.22 | -0.03 | -0.02 |
| 196 | -3.70 | -0.01 | -4.62 | 1.11  | 1.89  | 0.10  | -0.13 | 0.40  | 0.08  | -0.11 | 0.14  |
| 197 | -2.81 | 0.87  | -4.31 | 1.04  | 2.08  | 0.61  | 0.25  | 0.60  | 0.94  | -0.27 | -0.05 |
| 198 | -2.69 | 1.67  | -3.93 | 0.55  | 2.39  | 0.59  | 0.70  | 0.05  | 0.60  | 0.22  | -0.22 |
| 199 | -1.81 | 2.48  | -3.62 | -0.19 | 2.82  | 0.72  | 0.87  | -0.15 | -0.22 | 0.25  | 0.22  |
| 200 | -1.57 | 2.46  | -3.09 | -0.97 | 2.57  | 0.75  | 0.66  | -0.57 | -0.40 | -0.28 | 0.22  |
| 201 | -0.10 | 2.20  | -2.38 | -0.58 | 1.26  | 0.24  | -0.05 | -1.32 | 0.16  | 0.33  | -0.19 |
| 202 | -0.26 | 2.46  | -1.78 | -0.48 | -0.09 | -0.73 | -0.36 | -0.79 | 0.44  | 0.47  | 0.23  |
| 203 | 0.70  | 3.06  | -1.06 | -0.95 | -1.18 | -1.03 | -0.53 | 0.40  | 0.37  | -0.44 | 0.25  |
| 204 | 0.04  | 3.37  | -1.15 | -1.32 | -1.92 | -1.01 | -0.39 | 0.76  | 0.10  | 0.05  | -0.11 |





Table D.2. Cont'

|     |       |       |       |       |       |       |       |       |       |       |       |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 205 | 0.33  | 3.62  | -1.45 | -1.71 | -2.05 | -0.30 | 0.03  | 0.39  | 0.38  | -0.01 | -0.15 |
| 206 | -0.62 | 3.39  | -0.97 | -1.61 | -2.05 | 0.38  | 0.11  | -0.39 | -0.05 | -0.16 | 0.23  |
| 207 | -0.10 | 3.40  | 0.01  | -1.17 | -1.71 | 0.13  | 0.19  | -0.48 | -0.29 | -0.02 | 0.17  |
| 208 | -0.32 | 3.41  | 0.12  | -1.20 | -1.61 | -0.27 | -0.31 | 0.15  | -0.08 | -0.02 | -0.04 |
| 209 | 0.20  | 3.80  | -0.01 | -1.82 | -1.16 | 0.06  | -0.61 | 0.29  | 0.45  | -0.17 | 0.0   |
| 210 | -0.62 | 3.34  | -0.31 | -2.59 | -0.69 | 0.24  | 0.16  | -0.13 | 0.16  | -0.54 | 0.13  |
| 211 | -0.92 | 3.77  | -0.24 | -2.69 | -0.23 | 0.14  | 0.58  | -0.26 | -0.04 | -0.48 | 0.12  |
| 212 | -2.06 | 4.46  | 0.78  | -2.54 | 0.11  | -0.48 | 0.90  | -0.01 | -0.04 | -0.04 | -0.07 |
| 213 | -2.05 | 4.92  | 1.09  | -2.30 | -0.01 | -0.90 | 0.84  | 0.17  | -0.09 | 0.10  | 0.17  |
| 214 | -2.76 | 5.03  | 1.60  | -2.28 | 0.10  | -0.88 | 0.45  | -0.12 | -0.06 | -0.28 | 0.22  |
| 215 | -2.21 | 5.39  | 1.94  | -2.28 | -0.12 | -0.52 | 0.15  | -0.42 | 0.04  | -0.20 | 0.12  |
| 216 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 | 99.99 |
| 217 | -2.51 | 5.06  | 2.20  | -2.37 | -0.61 | 0.39  | 0.59  | -0.32 | -0.41 | -0.30 | 0.01  |
| 218 | -3.51 | 4.74  | 2.05  | -2.39 | -0.81 | 0.41  | 0.77  | -0.11 | -0.48 | -0.24 | -0.30 |
| 219 | -3.69 | 4.80  | 2.19  | -2.00 | -1.17 | 0.47  | 0.52  | 0.07  | -0.38 | -0.22 | -0.15 |
| 220 | -5.13 | 4.47  | 1.77  | -1.31 | -1.32 | 0.44  | 0.23  | 0.18  | -0.11 | -0.26 | 0.04  |
| 221 | -5.02 | 4.67  | 1.33  | -0.22 | -1.18 | -0.19 | 0.18  | 0.08  | 0.05  | -0.12 | 0.04  |
| 222 | -5.87 | 4.01  | 0.21  | 0.33  | -0.80 | -0.73 | -0.32 | 0.63  | -0.24 | -0.02 | -0.09 |
| 223 | -4.83 | 3.93  | -0.43 | 0.75  | -0.33 | -1.02 | -1.13 | 0.48  | -0.11 | 0.16  | -0.13 |
| 224 | -4.77 | 3.55  | -1.04 | 0.84  | 0.38  | -1.11 | -1.04 | 0.06  | -0.06 | 0.31  | -0.11 |
| 225 | -3.37 | 3.48  | -1.47 | 1.05  | 0.80  | -1.30 | -0.95 | -0.20 | -0.30 | 0.19  | -0.0  |
| 226 | -3.46 | 2.69  | -1.31 | 0.43  | 1.87  | -1.96 | -0.35 | -0.23 | -0.43 | 0.03  | -0.16 |
| 227 | -2.26 | 2.88  | -1.19 | -0.03 | 1.80  | -1.68 | -0.05 | 0.20  | -0.58 | -0.12 | -0.08 |
| 228 | -1.98 | 2.48  | -1.40 | -0.22 | 1.48  | -0.84 | 0.83  | 0.79  | -0.25 | -0.11 | -0.06 |
| 229 | -0.34 | 1.41  | -1.55 | -0.39 | 1.24  | -0.29 | 0.86  | 0.66  | -0.22 | 0.24  | 0.31  |
| 230 | -0.74 | 0.01  | -1.30 | -0.55 | 1.28  | 0.08  | 0.72  | 0.34  | 0.02  | 0.17  | 0.19  |
| 231 | -0.02 | -0.72 | -1.15 | -0.16 | 0.43  | 0.51  | 0.28  | -0.20 | 0.14  | -0.02 | -0.11 |
| 232 | -0.55 | -1.66 | -0.66 | -0.11 | -0.36 | 0.46  | 0.04  | -0.79 | 0.04  | 0.31  | -0.03 |
| 233 | 0.35  | -1.65 | -0.34 | -0.11 | -1.55 | 0.15  | -0.10 | -0.03 | -0.07 | 0.08  | -0.12 |
| 234 | 0.36  | -1.72 | -0.21 | -0.47 | -1.92 | 0.49  | -0.59 | 0.83  | 0.01  | -0.16 | -0.12 |
| 235 | 1.18  | -1.44 | -0.41 | -0.88 | -1.39 | 0.67  | -0.86 | 0.63  | 0.02  | -0.03 | 0.20  |
| 236 | 0.59  | -1.27 | -0.68 | -1.14 | -1.13 | 1.00  | -0.74 | 0.63  | -0.09 | 0.01  | 0.36  |
| 237 | 1.09  | -0.35 | -0.58 | -1.20 | -1.09 | 0.68  | -0.36 | 0.33  | -0.19 | 0.06  | 0.05  |
| 238 | 0.01  | 0.24  | -0.10 | -1.59 | -1.10 | 0.57  | 0.22  | 0.17  | -0.19 | 0.04  | -0.07 |
| 239 | 0.08  | 1.27  | -0.07 | -1.04 | -0.99 | 0.03  | 0.11  | 0.13  | -0.13 | 0.22  | 0.04  |
| 240 | -1.07 | 1.68  | 0.31  | -1.12 | -0.83 | -0.26 | -0.32 | 0.27  | -0.47 | 0.26  | -0.10 |



## APPENDIX E

(Southern Data Set)

Figure E.1 to E.11.

Phase-angle versus Time for space-waves of wave number 1 to 11, respectively. Time is indicated as days after November 23, 1976. These angles are uncorrected, that is, the angles are restricted to values between  $\pm 180$ .



Figure E.1.

Wave Number 1

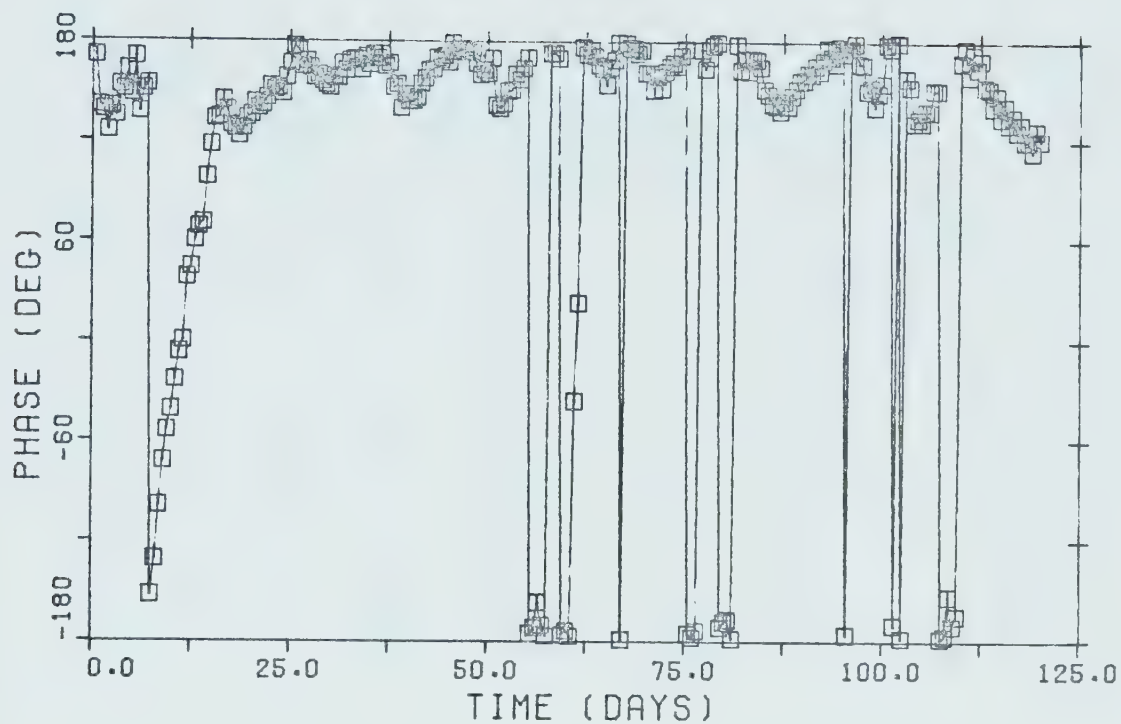


Figure E.2.

Wave Number 2

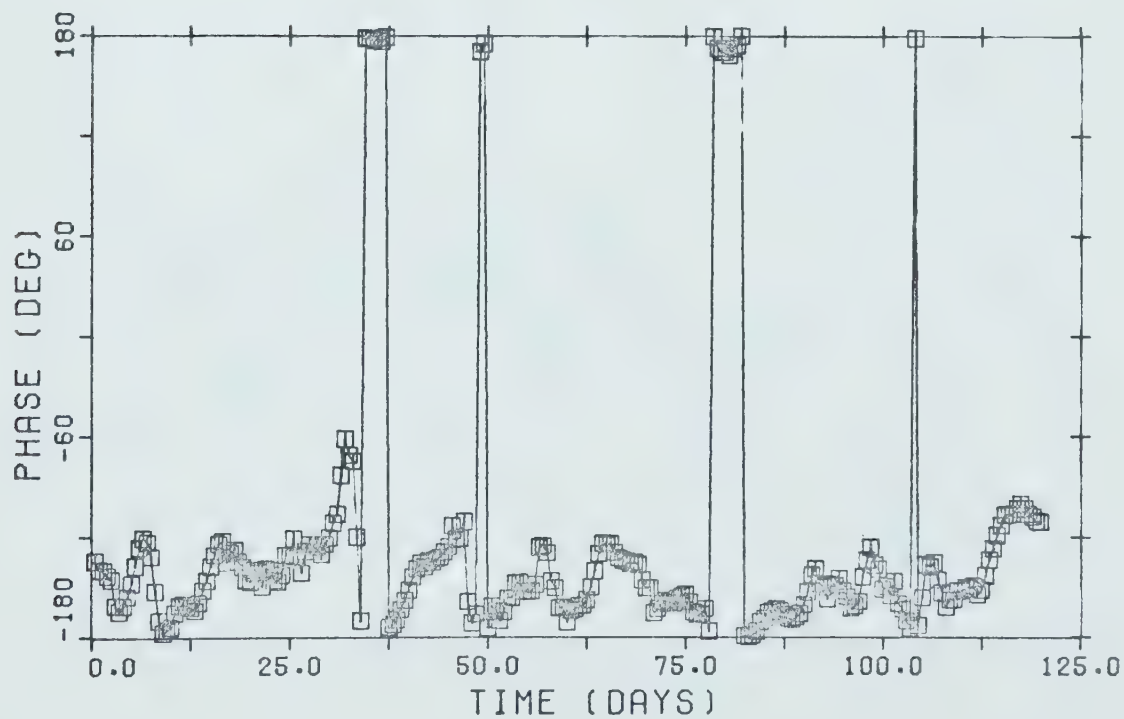




Figure E.3.

Wave Number 3

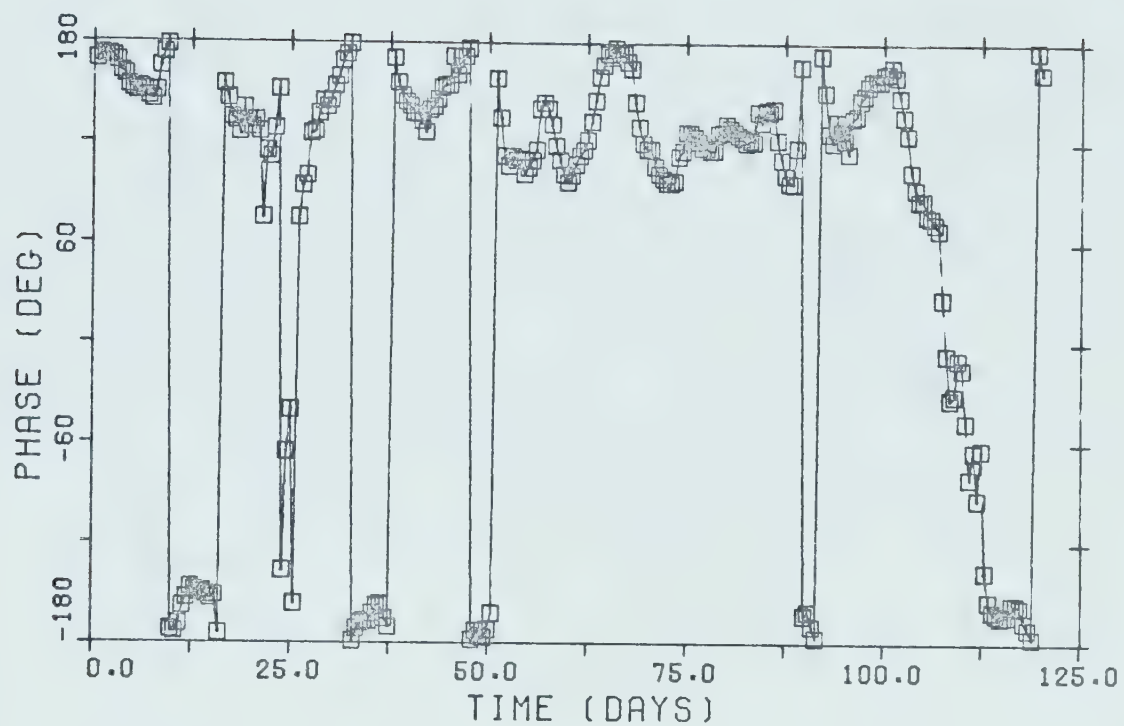


Figure E.4.

Wave Number 4

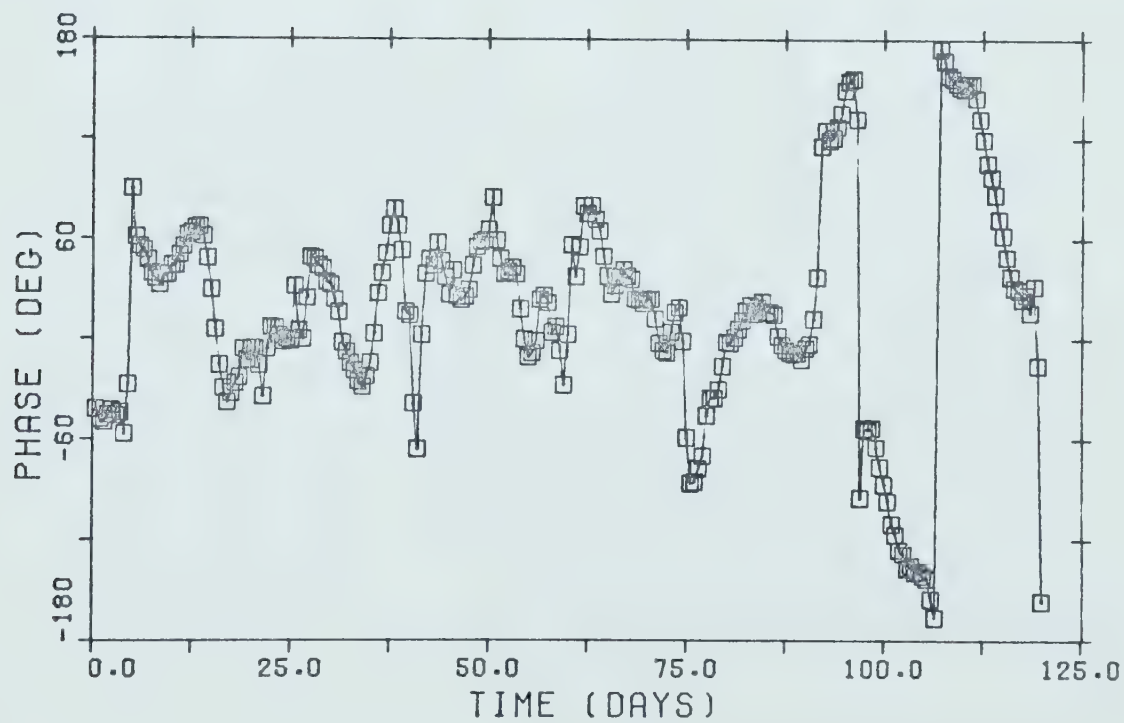






Figure E.5.

Wave Number 5

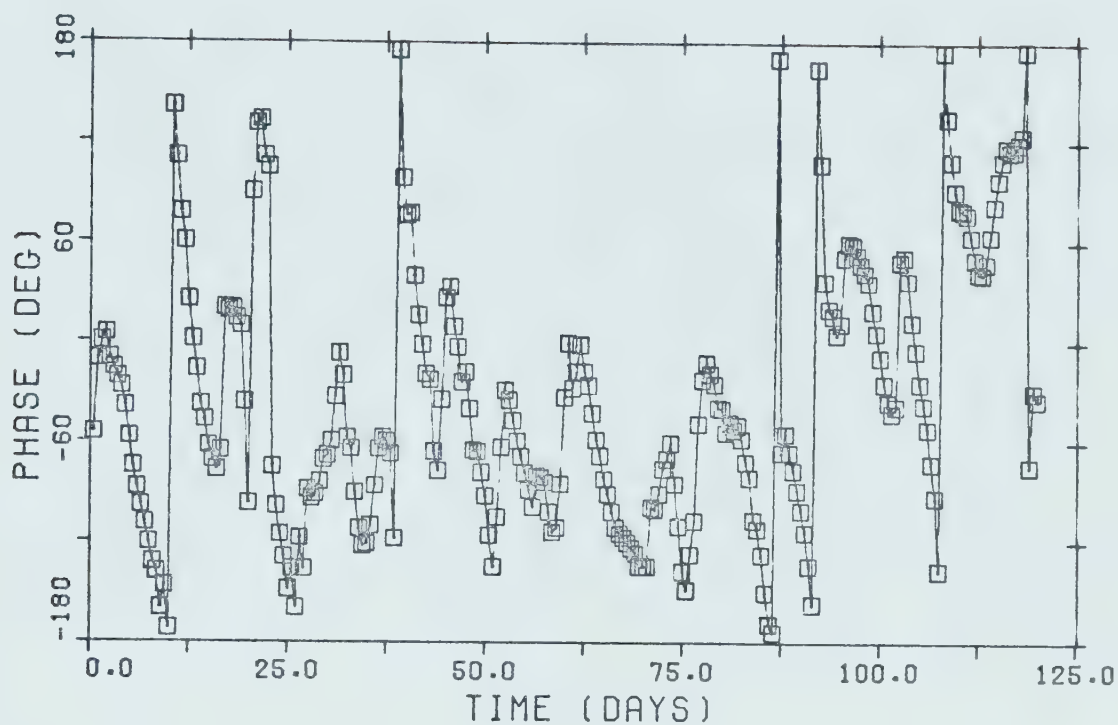


Figure E.6.

Wave Number 6

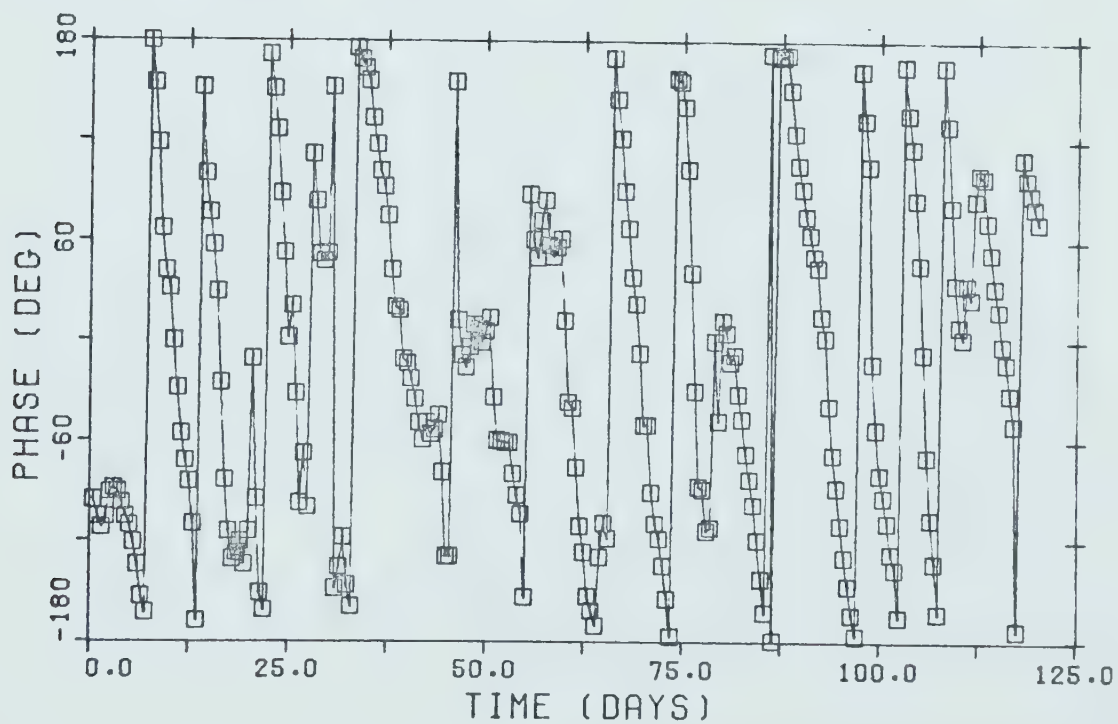




Figure E.7.

Wave Number 7

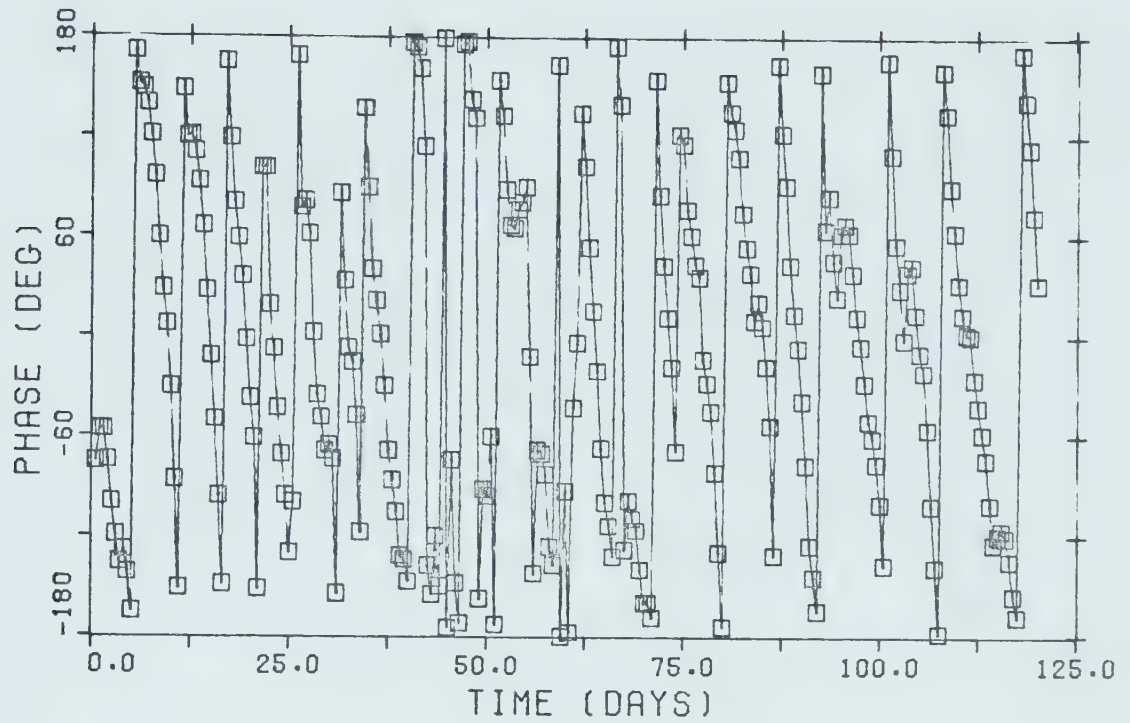


Figure E.8.

Wave Number 8

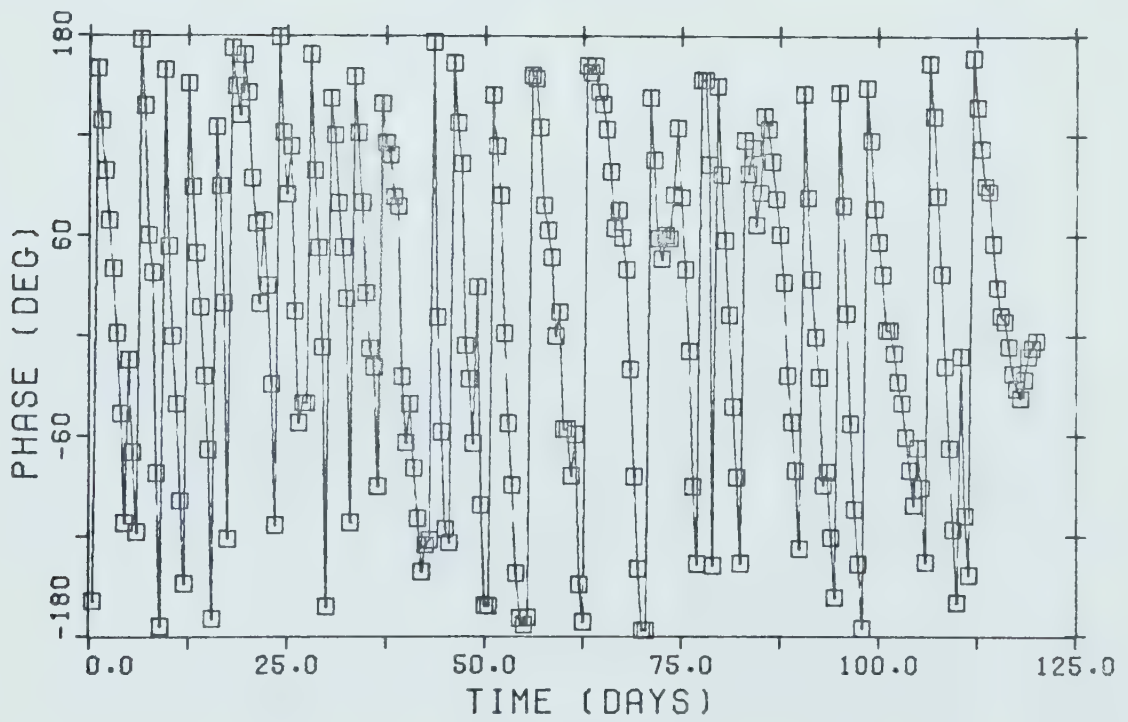




Figure E.9. Wave Number 9

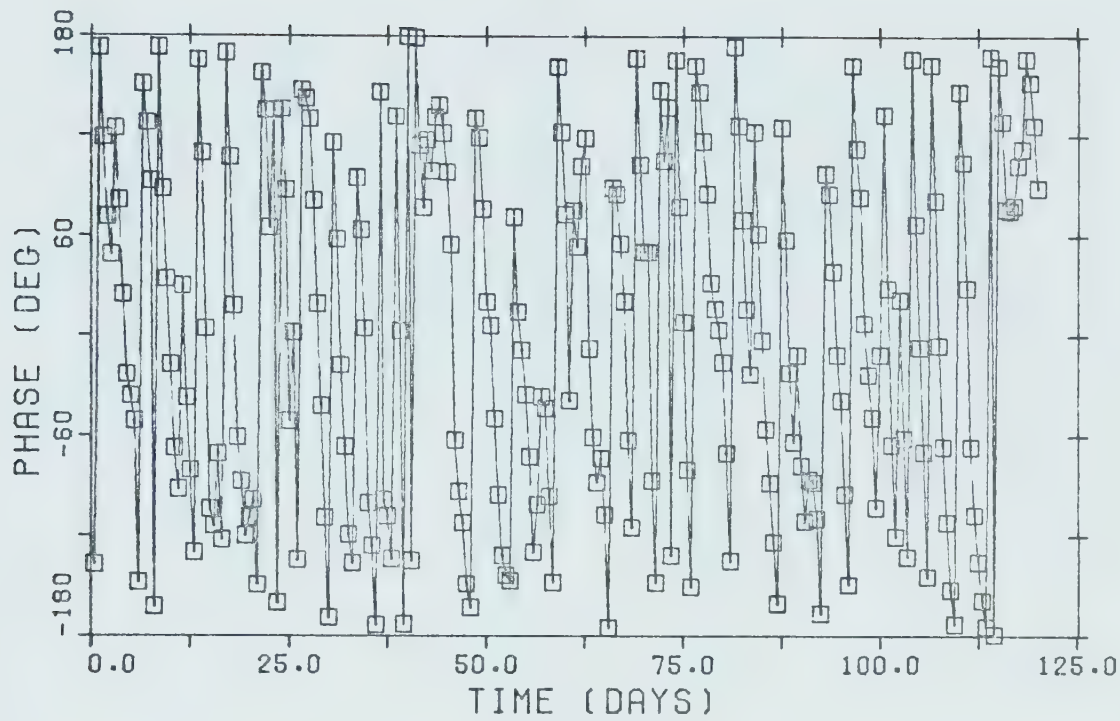


Figure E.10. Wave Number 10

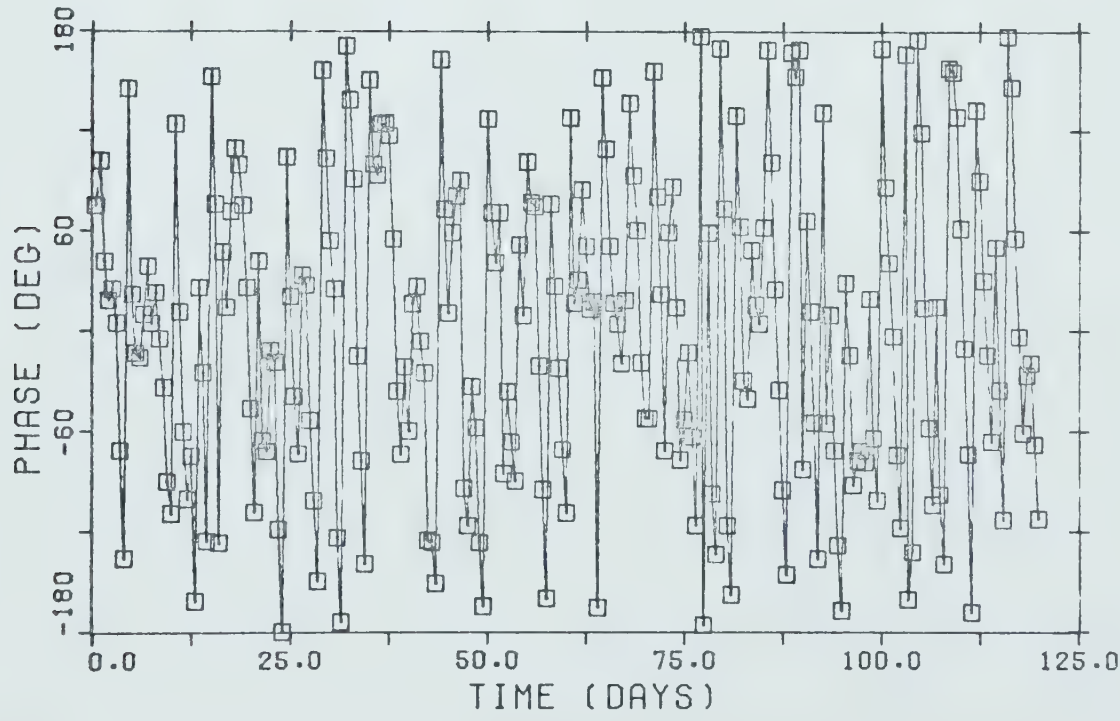
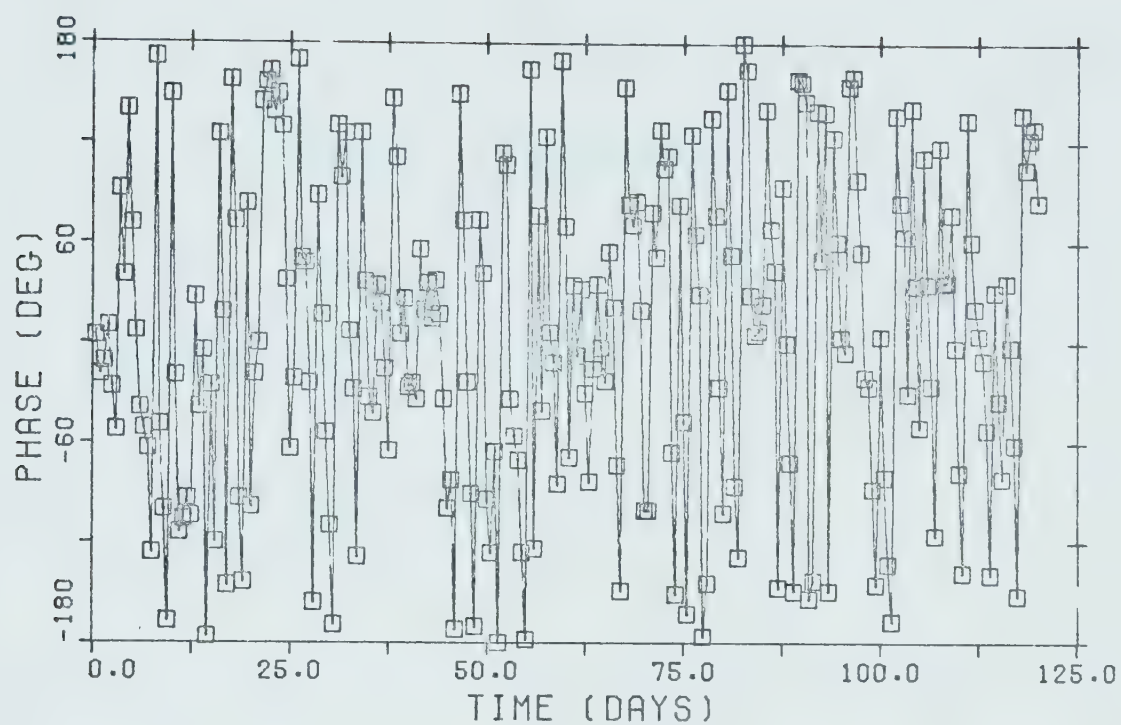




Figure E.11.

Wave Number 11







## APPENDIX F

### WAVE SPEED CALCULATION

Mean radius of Earth  $6371\text{km} = R_0$  , at  $45^\circ$  - distance  
from axis  $= R_0 \cos 45^\circ = 4520\text{km} = R$

let no. of degrees phase change per day  $= \alpha$   
and the wave no.  $= m$

circumference  $= 2\pi R = 2\pi \cdot 4520\text{km} \text{ (at } 45^\circ) = 28,400\text{km}$

wavelength  $= \lambda$   
 $= \frac{2\pi R}{m} = \frac{28,400}{m} \text{ km}$

get distance travelled/day by

$$\begin{aligned} &= \frac{\alpha}{360} \cdot \lambda \\ &= \frac{\alpha}{360} \cdot \frac{28,400}{m} \end{aligned}$$

if  $m = 2$ ,  $\alpha = 1.029$

$$\begin{aligned} \text{then distance travelled per day} &= 40.6 \frac{\text{km}}{\text{day}} \\ &= 1.69 \frac{\text{km}}{\text{hr}} \\ &\approx 0.9 \text{ kt} \end{aligned}$$



## APPENDIX G

### LISTING AND OUTPUT OF PART 1 OF THE HEIGHT FORECAST PROGRAM

#### Files Needed

|     | Number |                                                                    |
|-----|--------|--------------------------------------------------------------------|
| IN  | 1      | -Stores old trend parameters                                       |
| OUT | 2      | -Temporary storage for new trend Parameters                        |
| IN  | 3      | -Program parameters - see Appendix I<br>also see Format 7 line 193 |
| OUT | 4      | -Temporary storage for means of reports                            |
| IN  | 5      | -New "k" reports to be input                                       |
| OUT | 7      | -Temporary storage for updated AAMPL matrix                        |
| OUT | 8      | -Temporary storage for updated BAMPL matrix                        |
| OUT | 9      | -Trend values storage                                              |
| OUT | 10     | -Deviations from trend - storage                                   |
| IN  | 11     | -Old BAMPL matrix                                                  |
| IN  | 12     | -Old AAMPL matrix                                                  |
| IN  | 13     | -Old means of reports                                              |
| OUT | 14     | -Temporary storage for updated program<br>parameters               |

#### Where

IN = needed as input  
OUT = needed for output



### How to Start up Program:

- 1) set first line in files 11, 12 and 13 to zero
- 2) set first line in file 1 to zero (75 columns)
- 3) set second line in file 1 to zero with a 1 in column 65
- 4) set NUMB = 0 and JI = 1 in file 3

### Format of New Data

Three cards are required:

Card 1: Heights 1 to 24 in the first 72 columns and date in next 8 columns (see lines 36 and 37)

Card 2: Heights 25 to 48 in first 72 columns and any other parameter in the next 4 columns

Card 3: Heights 49 to 72 in first 72 columns and U,V (zonal and south wind).  
U and V are not used in this program.

See Table G.1. for a sample output of Part 1 of the program.

Once the Program is complete, the temporary files 2, 4, 7, 8 and 14 are copied to files 1, 13, 12, 11 and 3, respectively.



```

1  C
2  C
3  C***** PART 1 *****
4  C      HEIGHT FORECAST PROGRAM
5  C
6  C
7      DIMENSION BUF(400)
8      DIMENSION DATA(72),AAMP(300,11),BAMP(300,11)
9      INTEGER DATE,DAY,YEAR
10     COMMON FREQ(151),A(151),B(151),AA(151)
11     COMMON /NO2/Y(300)
12     READ(5,1)K
13  C  ** K=NUMBER OF NEW REPORTS TO BE READ IN
14     1  FORMAT(I3)
15  C  ** CHECK STORAGE DATA BLOCK SIZE
16     READ(11,3)KLA2
17     READ(12,3)KLA1
18     3  FORMAT(I5)
19     IF(KLA2.NE.KLA1)GO TO 500
20     READ(13,4)LEN,JH,JD,JM,JY
21  C  ** LEN=NUMBER OF MEANS OF REPORTS STORED
22  C  ** JY,JM,JD,JH=YEAR,MONTH,DAY,HOUR OF LAST REPORT
23     4  FORMAT(I5,4I3)
24     WRITE(6,8)JY,JM,JD,JH
25     8  FORMAT(' ','DATE OF LAST DATA',4I3)
26     IF(KLA2.NE.LEN)GO TO 500
27     IF(LEN.EQ.0)GO TO 20
28     READ(13,63)(BUF(L),L=1,LEN)
29     READ(12,32)((AAMP(J,L),L=1,11),J=1,LEN)
30     READ(11,32)((BAMP(J,L),L=1,11),J=1,LEN)
31     20  ITIM=LEN+K
32  C  ** READ IN NEW REPORTS
33  C  IF K AMOUNT OF REPORTS NOT AVAILABLE GO TO 15
34  C  ** ITIM =TOTAL NUMBER OF REPORTS (OLD +NEW)
35     DO 2 I=1,K
36     READ(5,5,END=15)(DATA(L),L=1,24),JHR,DAY,JMON,YEAR
37     5  FORMAT(24F3.0,4I2)
38     READ(5,6)(DATA(L),L=25,48),DATE
39     6  FORMAT(24F3.0,I4)
40     READ(5,7)(DATA(L),L=49,72),U,V
41     7  FORMAT(24F3.0,F4.1,F4.1)
42  C  ** PRINT OUT NEW DATA
43     WRITE(6,16)YEAR,JMON,DAY,JHR
44     16  FORMAT(' ','DATE OF NEW DATA ',4(1X,I2))
45     DO 18 N=1,3
46     ML=(N-1)*24
47     MA=1+ML
48     MB=24+ML
49     18  WRITE(6,17)(DATA(L),L=MA,MB)
50     17  FORMAT(' ',24F4.0)
51     59  L=72
52     SUM=0.00

```





```

53      XL=FLOAT(L)
54      NOZRO=0
55  C  ** CHECK FOR MISSING DATA
56  C  NOZRO=NUMBER OF HEIGHTS OF VALUE ZERO
57      DO 50 J=1,L
58      IF(DATA(J).EQ.0.00)NOZRO=NOZRO+1
59  50  SUM=SUM+DATA(J)
60  C  ** CALCULATE MEANS
61      ANOT=SUM/XL
62      IK=I+LEN
63      BUF(IK)=ANOT
64      DO 12 J=1,L
65  C  ** REMOVE MEAN FROM REPORT HEIGHTS
66  12  DATA(J)=DATA(J)-ANOT
67      DEL=5.0
68      IF(NOZRO.GT.35)GO TO 13
69  C  ** TAKE FOURIER ANALYSIS OF DATA
70      CALL SPEC(DATA,L,DEL)
71  13  DO 31 J=1,11
72      IF(NOZRO.GT.10)A(J)=99.99
73      IF(NOZRO.GT.10)B(J)=99.99
74  C  ** UP-DATE DATA BLOCKS
75      AAMP(IK,J)=A(J)
76  31  BAMP(IK,J)=B(J)
77      2  CONTINUE
78  C  ** MA=START POINT, ITIM=END POINT
79      MA=1
80      ITI=ITIM
81      IF(ITIM.LT.300)GO TO 19
82  C  ** IF NEEDED, SHIFT START AND END POINTS
83      MA=ITIM-299
84      ITI=300
85  19  WRITE(6,60)ITI
86  60  FORMAT(' ',I5)
87      JJ=0
88      DO 21 L=MA,ITIM
89      JJ=JJ+1
90  C  ** RENUMBER AND STORE MEANS OF REPORTS
91      Y(JJ)=BUF(L)
92  21  CONTINUE
93      WRITE(6,61)(BUF(L),L=MA,ITIM)
94  61  FORMAT(' ',11F7.3)
95      WRITE(4,4)ITI,JHR,DAY,JMON,YEAR
96      WRITE(7,62)ITI
97      WRITE(8,62)ITI
98      WRITE(4,63)(BUF(L),L=MA,ITIM)
99      WRITE(7,32)((AAMP(J,L),L=1,11),J=MA,ITIM)
00      WRITE(8,32)((BAMP(J,L),L=1,11),J=MA,ITIM)
01  32  FORMAT(11F7.2)
02  62  FORMAT(I5)
03  63  FORMAT(11F7.3)
04  C  ** GO ON TO NEXT STEP IN PROGRAM

```



```

105      CALL WAVE(LEN,K)
106      10 STOP
107      15 WRITE(6,700)
108      C ** WARNING ** K VALUE TOO LARGE
109      700 FORMAT(1H1,' DATA END HAS BEEN REACHED')
110      GO TO 2
111      500 WRITE(6,501)
112      C ** ERROR ** DATA BLOCKS OF DIFFERENT SIZES
113      501 FORMAT(' ','KLA2,KLA1,LEN IN CONFLICT')
114      STOP
115      END
116
117      C
118      C***** TAKE SPECTRAL ANALYSIS OF S(N) *****
119      C
120      SUBROUTINE SPEC(S,N,DEL)
121      DIMENSION S(300),R(150),Q(150)
122      COMMON FREQ(151),A(151),B(151),AA(151)
123      DATA TOPI/6.2831853/
124      K=N/2
125      L=N/2 + 1
126      1 FORMAT(I5)
127      2 FORMAT(' ',11F7.3)
128      V=FLOAT(L)
129      W=FLOAT(N)
130      DO 3 M=1,K
131      SUM1=0.00
132      SUM2=0.00
133      U=FLOAT(M)
134      C ** CALCULATE AMPLITUDE/2
135      DO 4 I=1,N
136      X=FLOAT(I)
137      D=TOPI*U*(X-V)/W
138      SUM1=SUM1+S(I)*COS(D)
139      4 SUM2=SUM2+S(I)*SIN(D)
140      A(M)=SUM1/W
141      3 B(M)=SUM2/W
142      SUM=0.00
143      C ** FIND MEAN OF S(N) AND STORE IN A(L)
144      DO 5 J=1,N
145      5 SUM=SUM+S(J)
146      A(L)=SUM/W
147      SUM=0.00
148      C ** FIND MEAN-SQUARE OF S(N) MEAN
149      AA(L)=A(L)*A(L)
150      SUM=SUM+AA(L)
151      R(L)=ABS(A(L))
152      DO 7 J=1,K
153      ZJ=FLOAT(J)
154      FREQ(J)=ZJ/(DEL*W)
155      R(J)=SQRT(A(J)*A(J) + B(J)*B(J))
156      IF(A(J).EQ.0.00)A(J)=0.0000001

```



```

157 C ** FIND PHASE
158   Q(J)=ATAN2(-B(J),A(J))*360./TOP1
159 C ** FIND MEAN-SQUARE
160   AA(J)=R(J)*R(J)*2.
161   IF(J.EQ,K)AA(J)=AA(J)/2.
162 C ** SUM=VARIANCE=TOTAL MEAN-SQUARE OF WAVES
163   SUM=SUM+AA(J)
164   IF(J.GT.40)GO TO 7
165   7 CONTINUE
166   FREQ(L)=0.000
167   IF(A(L).EQ.0.00)A(L)=0.0000001
168   Q(L)=ATAN2(-0.00,A(L))*360./TOP1
169   RETURN
170   END
171 C
172 C**** CALCULATE TREND PARAMETERS AND COEFFICIENTS
173 C      USING LEAST SQUARE FIT TO SINE-COSINE CURVE
174 C      (SEE APPENDIX B)
175 C      SUBROUTINE WAVE(LEN,K)
176 C      JI= STARTING POINT OF DIAGONISTIC DATA
177 C      LEN=LENGTH OF BLOCKS=NUM
178 C      KLAST= NO OF POINTS OF ORIGINAL DATA
179 C      J=POINT WHERE TREND STARTS
180 C      IEND=NO OF POINTS+1 THAT WERE USED TO CALCULATE
181 C      THE STORED TREND PARAMETERS
182 C      ILAST=NO OF POINTS TO BE USED FOR THE NEW TREND
183 C      CALCULATION
184   DIMENSION Y(300),Y0(400),ZZ(300)
185   COMMON /NO2/Y
186   COMMON /NO3/Y0,ZZ
187   DATA PI/3.141593/
188   READ(3,7)IWAVE,RO,L,DIV,NWAVE,NUMB,RMS,JI
189 C ** RMS=SQUARE ROOT OF VARIANCE OF DIFFERENCES
190 C      FROM TREND
191 C ** JI=START OF DATA IN DATA BLOCKS =1 ALWAYS
192 C ** L= NUMBER OF FORECASTS TO BE MADE
193   7 FORMAT(I5,F8.3,I5,F8.3,I5,I5,F7.3,I5)
194   Z=(2.*PI)/730.
195   IF(LEN.NE.NUMB)WRITE(6,99)
196   99 FORMAT(' ','LEN NOT = NUMB')
197 C ** READ IN STORED TREND PARAMETERS
198   READ(1,44)T,W,S,P,Q
199   READ(1,45)E,F,G,AN,IEND
200   44 FORMAT(5E15.8)
201   45 FORMAT(4E15.8,I5)
202   ILAST=IEND+K-1
203   KLAST=LEN+L+K
204   J=LEN
205   LEN=LEN+K
206 C ** LEN NOW REPRESENTS LENGTH OF ALL DATA
207   NUMB=LEN
208   WRITE(6,44)T,W,S,P,Q

```



```

209      WRITE(6,47)
210 47 FORMAT(' ',4X,'J',7X,'X',14X,'Y',13X,'COS',13X,
211      1'SIN')
212      DO 3 I=IEND,ILAST
213      J=J+1
214      X=FLOAT(I)*Z
215      U=COS(X)
216      V=SIN(X)
217      A=Y(J)
218      IF(A.EQ.0.00)GO TO 3
219      T=T+U
220      W=W+V
221      S=S+(U*V)
222      P=P+(U*U)
223      Q=Q+(V*V)
224      E=E+(A*U)
225      F=F+(V*A)
226      G=G+A
227      AN=AN+1.
228      WRITE(6,46)J,X,A,U,V
229 46 FORMAT(' ',15,4E15.8)
230 3 CONTINUE
231      WRITE(2,44)T,W,S,P,Q
232      IST=ILAST+1
233      WRITE(2,45)E,F,G,AN,IST
234      R=T*S-P*W
235      D=((T*E-P*G)*(S*S-P*Q)-R*(S*E-P*F))
236      1/((S*S-P*Q)*(T*T-P*AN)-R*R)
237      C=((S*E-P*F)-R*D)/(S*S-P*Q)
238      H=(E-T*D-S*C)/P
239 C ** PRINT OUT TREND COEFFICIENTS
240      WRITE(6,4)D,H,C
241 4 FORMAT(' ',E13.5,' +',E13.5,' COS +',E13.5,' SIN')
242      ILAST=ILAST+L
243      CALL TREND(LEN,D,B,C,ILAST,L)
244      CALL DIFF(NUMB,LEN,JI,RMS)
245      WRITE(14,7)IWAVE,RO,L,DIV,NWAVE,NUMB,RMS,JI
246      STOP
247      END
248 C
249 C**** TREND FORECAST ****
250 C
251      SUBROUTINE TREND(LEN,D,B,C,KLAST,JI,IEND,ILAST,L)
252      DIMENSION YO(400),ZZ(300)
253      COMMON /NO3/YO,ZZ
254      DATA PI/3.141593/
255      Z=(2.*PI)/730.
256 C ** FIND START-POINT OF TREND TO FIT DATA BLOCKS
257      MA=ILAST-LEN-L+1
258 C ** IAST=END POINT OF TREND OT MATCH DATA BLOCK
259      IAST=ILAST-L
260 C ** ILAST=END-POINT OF FORECAST PERIOD

```





```

261      WRITE(6,3)MA,IAST,ILAST
262      3 FORMAT(' ','TREND FROM',I6,' TO',I6,' EXTENDE',
263      1' TO',I6,' POINTS - SPACED EVERY 10')
264      J=0
265      C ** GENERATE TREND FOR DIAGNOSTIC PERIOD AND
266      C FOR FORECAST PERIOD
267      DO 1 I=MA,ILAST
268      J=J+1
269      X=FLOAT(I)*Z
270      YO(J)=D+B*COS(X)+C*SIN(X)
271      1 CONTINUE
272      C ** STORE AND PRINT OUT TREND
273      WRITE(9,4)J,MA
274      4 FORMAT(2I5)
275      WRITE(9,2)(YO(I),I=1,J)
276      WRITE(6,2)(YO(I),I=1,J,10)
277      2 FORMAT(' ',11F7.3)
278      RETURN
279      END
280      C
281      C**** CALCULATE DIFFERENCES ****
282      C
283      SUBROUTINE DIFF(NUMB,LEN,JI,RMS)
284      DIMENSION Y(300),X(400),Z(300)
285      COMMON /NO2/Y
286      COMMON /NO3/X,Z
287      DO 2 J=JI,LEN
288      IF(Y(J).EQ.0.000)GO TO 3
289      Z(J)=Y(J)-X(J)
290      GO TO 2
291      C
292      C ** SMOOTHING MISSING DATA
293      C THIS IS A SUBROUTINE IN PART 2 OF THE
294      C HEIGHT FORECAST PROGRAM
295      3 SUM=0.000
296      M=7
297      MM=M
298      C USE A 7 POINT SMOOTHER FOR MISSING DATA
299      DO 4 I=1,MM
300      IF(J.LT.(JI+3))GO TO 5
301      IF(J.GT.(LEN-3))GO TO 5
302      N=J-4+I
303      IF(Y(N).EQ.0.000)GO TO 5
304      SUM=SUM+Y(N)
305      GO TO 4
306      5 M=M-1
307      4 CONTINUE
308      IF(M.LE.0)GO TO 7
309      SUM=SUM/FLOAT(M)
310      Z(J)=SUM-X(J)
311      GO TO 2
312      7 Z(J)=0.000

```



```

313 C
314 2 CONTINUE
315 C ** CALCULATE MEAN AND VARIANCE
316 SUM1=0.000
317 SUM2=0.000
318 K=LEN-JI+1
319 DO 8 J=JI,LEN
320 SUM2=SUM2+(Z(J)*Z(J))
321 8 SUM1=SUM1+Z(J)
322 SMEAN=SUM1/K
323 VAR=SUM2/(K-1)
324 WRITE(6,12)JI,LEN
325 12 FORMAT(' ', 'DIFFERENCE BETWEEN 12HR MEAN AND TREND'
326 1, ' FROM ', I5, ' TO ', I5)
327 JO=LEN-NUMB+1
328 WRITE(10,9)NUMB
329 9 FORMAT(I5)
330 C ** PRINT OUT DIFFERENCES
331 WRITE(10,11)(Z(J),J=JO,LEN)
332 WRITE(6,11)(Z(J),J=JI,LEN)
333 11 FORMAT(' ', 11F7.3)
334 WRITE(6,10)SMEAN,VAR
335 C ** CALCULATE RMS
336 RMS=SQRT(VAR)
337 10 FORMAT(' ', 6X, 'MEAN=', F10.3, 6X, 'VARIANCE=', F10.3)
338 RETURN
339 END

```



Table G.1. OUTPUT OF PART 1

| Table G.1.                                                    |                                 |                                 |                                 |                                 | OUTPUT OF PART 1 |    |    |   |   |
|---------------------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|------------------|----|----|---|---|
| DATE OF LAST DATA                                             | 0                               | 0                               | 0                               | 0                               | DATE OF NEW DATA | 76 | 12 | 1 | 0 |
| 25. 25. 23. 20. 18. 16. 15. 15.                               | 19. 21. 23. 24. 25. 27. 28. 29. | 21. 22. 23. 24. 25. 26. 27. 28. | 21. 22. 23. 24. 25. 26. 27. 28. | 21. 22. 23. 24. 25. 26. 27. 28. |                  |    |    |   |   |
| 11. 13. 16. 19. 21. 23. 23. 20.                               | 17. 19. 14. 13. 11. 1. 1. 10.   | 1. 1. 1. 1. 1. 1. 1. 10.        | 1. 1. 1. 1. 1. 1. 1. 10.        | 1. 1. 1. 1. 1. 1. 1. 10.        |                  |    |    |   |   |
| 26. 34. 42. 48. 51. 54. 51. 46.                               | 27. 27. 16. 6. 1. 25. 2. 1.     | 3. 3. 3. 3. 3. 3. 3. 10.        | 3. 3. 3. 3. 3. 3. 3. 10.        | 3. 3. 3. 3. 3. 3. 3. 10.        |                  |    |    |   |   |
| DATE OF NEW DATA                                              | 76                              | 12                              | 1                               | 0                               | DATE OF NEW DATA | 76 | 12 | 1 | 0 |
| 23. 21. 19. 15. 13. 12. 12. 12.                               | 12. 15. 18. 23. 26. 28. 28. 29. | 29. 29. 29. 29. 29. 29. 29. 29. | 29. 29. 29. 29. 29. 29. 29. 29. | 29. 29. 29. 29. 29. 29. 29. 29. |                  |    |    |   |   |
| 15. 14. 14. 16. 19. 21. 24. 25.                               | 25. 24. 21. 18. 17. 1. 1. 18.   | 23. 23. 23. 23. 23. 23. 23. 23. | 23. 23. 23. 23. 23. 23. 23. 23. | 23. 23. 23. 23. 23. 23. 23. 23. |                  |    |    |   |   |
| 25. 29. 34. 39. 44. 48. 47. 46.                               | 41. 32. 22. 12. 3. 0. 0. 0.     | 3. 3. 3. 3. 3. 3. 3. 10.        | 3. 3. 3. 3. 3. 3. 3. 10.        | 3. 3. 3. 3. 3. 3. 3. 10.        |                  |    |    |   |   |
| DATE OF NEW DATA                                              | 76                              | 12                              | 2                               | 0                               | DATE OF NEW DATA | 76 | 12 | 2 | 0 |
| 20. 20. 18. 14. 10. 7. 5. 7.                                  | 8. 10. 13. 17. 23. 27. 28. 31.  | 31. 31. 31. 31. 31. 31. 31. 31. | 31. 31. 31. 31. 31. 31. 31. 31. | 31. 31. 31. 31. 31. 31. 31. 31. |                  |    |    |   |   |
| 19. 18. 17. 14. 15. 16. 19. 22.                               | 24. 25. 24. 22. 21. 21. 23. 22. | 21. 21. 21. 21. 21. 21. 21. 21. | 21. 21. 21. 21. 21. 21. 21. 21. | 21. 21. 21. 21. 21. 21. 21. 21. |                  |    |    |   |   |
| 20. 31. 33. 34. 36. 38. 39. 39.                               | 36. 34. 27. 19. 11. 1. 5. 5.    | 5. 5. 5. 5. 5. 5. 5. 10.        | 5. 5. 5. 5. 5. 5. 5. 10.        | 5. 5. 5. 5. 5. 5. 5. 10.        |                  |    |    |   |   |
| DATE OF NEW DATA                                              | 76                              | 12                              | 3                               | 0                               | DATE OF NEW DATA | 76 | 12 | 3 | 0 |
| 19. 17. 15. 12. 11. 9. 9. 9.                                  | 9. 16. 13. 17. 23. 21. 20. 23.  | 33. 33. 33. 33. 33. 33. 33. 33. | 33. 33. 33. 33. 33. 33. 33. 33. | 33. 33. 33. 33. 33. 33. 33. 33. |                  |    |    |   |   |
| 21. 20. 18. 17. 15. 15. 18. 18.                               | 20. 25. 27. 20. 29. 23. 23. 22. | 21. 21. 21. 21. 21. 21. 21. 21. | 21. 21. 21. 21. 21. 21. 21. 21. | 21. 21. 21. 21. 21. 21. 21. 21. |                  |    |    |   |   |
| 31. 33. 36. 37. 36. 35. 33. 33.                               | 29. 20. 23. 22. 15. 16. 6. 3.   | 3. 3. 3. 3. 3. 3. 3. 10.        | 3. 3. 3. 3. 3. 3. 3. 10.        | 3. 3. 3. 3. 3. 3. 3. 10.        |                  |    |    |   |   |
| DATE OF NEW DATA                                              | 76                              | 12                              | 3                               | 0                               | DATE OF NEW DATA | 76 | 12 | 3 | 0 |
| 17. 16. 14. 12. 10. 8. 7. 8.                                  | 9. 11. 15. 20. 25. 29. 33. 33.  | 33. 33. 33. 33. 33. 33. 33. 33. | 33. 33. 33. 33. 33. 33. 33. 33. | 33. 33. 33. 33. 33. 33. 33. 33. |                  |    |    |   |   |
| 23. 22. 19. 17. 16. 13. 13. 16.                               | 20. 24. 27. 28. 27. 23. 26. 25. | 25. 25. 25. 25. 25. 25. 25. 25. | 25. 25. 25. 25. 25. 25. 25. 25. | 25. 25. 25. 25. 25. 25. 25. 25. |                  |    |    |   |   |
| 33. 34. 35. 37. 36. 36. 36. 36.                               | 23. 25. 23. 21. 12. 12. 6. 6.   | 6. 6. 6. 6. 6. 6. 6. 6.         | 6. 6. 6. 6. 6. 6. 6. 6.         | 6. 6. 6. 6. 6. 6. 6. 6.         |                  |    |    |   |   |
| 5                                                             |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 20.208 20.347 70 764 21.625 22.778                            |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 0.0 J X Y C00 C01 C02                                         |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 1 0.86071007E-02 0.20208323E+02 0.99932999E+00 0.28069927E-02 |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 2 0.17214201E-01 0.20347214E+02 0.99980189E+00 0.17313249E-01 |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 3 0.25821302E-01 0.20783039E+02 0.99963669E+00 0.19012302E-01 |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 4 0.34428403E-01 0.21679900E+02 0.99910741E+00 0.31631641E-01 |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 5 0.43035503E-01 0.22777777E+02 0.99907777E+00 0.43333333E-01 |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 0.667102102 1 6.47486110E+05 1 6.713475E+0201N                |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| TREND FROM 1 10 0 EXTEND 10 35 POINTS - SPREAD EVERY 10       |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 10.045 26.378 23.150 40.291 17.507 94.906 22.352              |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| DIFFERENCE BETWEEN 12HR AHEAD AND TREND FROM 1 TO 5           |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| 0.344 -0.154 -0.777 -0.150 0.147                              |                                 |                                 |                                 |                                 |                  |    |    |   |   |
| THE NFAH - 0.000 THE NFAH - 0.167                             |                                 |                                 |                                 |                                 |                  |    |    |   |   |



## APPENDIX H

### LISTING OF PART 2 OF THE PROGRAM

#### Files Needed

|     | Number |                                                                   |
|-----|--------|-------------------------------------------------------------------|
| IN  | 3      | -Program parameters - see Appendix I<br>also see Format 6 line 37 |
| IN  | 9      | -Trend values storage<br>(from Part 1 of the program)             |
| IN  | 10     | -Deviations from trend - storage<br>(from Part 1 of the program)  |
| IN  | 11     | -Updated BAMPL matrix<br>(from Part 1 of the program)             |
| IN  | 12     | -Updated AAMPL matrix<br>(from Part 1 of the program)             |
| OUT | 14     | -Storage for forecasts of the AAMPL matrix                        |
| OUT | 15     | -Storage for forecasts of the BAMPL matrix                        |
| OUT | 16     | -Storage for forecasts of the deviations<br>from the trend        |
| OUT | 13     | -Storage for forecasts of heights                                 |

#### Where

IN = needed as input  
OUT = needed for output





```

: 1      C**** PART 2 ****
: 2      C
: 3      C
: 4          DIMENSION BUF(400)
: 5          COMMON /ND4/Z(400),AAMP(400,11),BAMP(400,11)
: 6          COMMON FREQ(151),R(151),Q(151),AA(151)
: 7      C ** CHECK SIZE OF STORED DATA BLOCKS
: 8          READ(11,1)NUMB
: 9          READ(10,1)NUMB1
10         READ(12,1)NUMB2
11         1 FORMAT(I5)
12         IF(NUMB1.NE.NUMB2)GO TO 900
13         IF(NUMB1.NE.NUMB)GO TO 900
14         GO TO 2
15     900 WRITE(6,100)NUMB,NUMB1,NUMB2
16     100 FORMAT(' ','DATA IN BLOCKS OF DIFFERENT SIZE',3I5)
17         STOP
18     C
19     C
20     C
21     C ** READ IN DIFFERENCES(MEAN-TREND)
22         2 READ(10,3)(Z(J),J=1,NUMB)
23         3 FORMAT(' ',11F7.3)
24     C ** READ IN STORED AMPLITUDES/2
25         READ(12,4)((AAMP(J,L),L=1,11),J=1,NUMB)
26         READ(11,4)((BAMP(J,L),L=1,11),J=1,NUMB)
27         4 FORMAT(11F7.2)
28     C ** READ IN PROGRAM PARAMETERS
29     C     IWAVE=NUMBER OF SORTED STRONG WAVES TO BE PRINTED
30     C     PRINT=OPTION INDICATOR
31     C     L=NUMBER OF FORECASTS TO BE MADE
32     C     DIV=JWAVE IN REAL FORMAT
33     C     NWAVE=MAXIMUM NUMBER OF TIME WAVES IN FORECAST
34     C     NUM=NUMB=LENGTH OF DIAGNOSTIC DATA BLOCKS
35     C     RMS,JI=PARAMETERS USED IN PART 1
36         READ(3,6)IWAVE,PRINT,L,DIV,NWAVE,NUM,RMS,JI
37         6 FORMAT(I5,F8.3,I5,F8.3,I5,I5,F7.3,I5)
38         WRITE(6,17)NUMB
39     17 FORMAT(' ','NUMBER OF DATA POINTS =',I5)
40     C
41     C
42     C
43     C
44         KLAST=NUMB+L
45         AMPLO=0.15
46     C ** AMPLO=MINIMUM AMPLITUDE ALLOWED FOR A FORECAST WAVE
47         DEL=12.0
48     C ** DEL=NUMBER OF HOURS BETWEEN REPORTS
49     C ** START TO OPERATE ON DIFFERENCES
50         WRITE(6,7)
51         7 FORMAT(' ','SPEC FROM MEAN-TREND DIFFERENCES')
52         CALL SPEC(Z,NUMB,DEL)
53         CALL SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)

```



```

54         IF(ABS(PRINT).GT.3.5)GO TO 5
55         CALL SPCSM(JJ,SUM,PRINT)
56     5 CALL SORT(IWAVE,JH,SUM,PRINT)
57         CALL FCST(NWAVE,RO,L,DEL,JI,NUMB,BUF,AMPLO,PRINT)
58         DO 18 I=1,KLAST
59     18 Z(I)=BUF(I)
60     C
61     C
62     C ** START TO OPERATE ON AMPLITUDES
63     C     IA=WAVE NUMBER COUNTER
64     C ** FIRST AAMPL
65         IA=1
66         JWAVE=DIV/1
67         DATMS=99.99
68     16 WRITE(6,11)IA
69     11 FORMAT(' ','SPEC FROM COS AMPLITUDES',8X,'WAVE NO',I5)
70         DO 10 I=1,NUMB
71     10 BUF(I)=AAMP(I,IA)
72         CALL SM7PT(BUF,NUMB,DATMS)
73         CALL SPEC(BUF,NUMB,DEL)
74         CALL SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)
75         IF(ABS(PRINT).GT.3.5)GO TO 8
76         CALL SPCSM(JJ,SUM,PRINT)
77     8 CALL SORT(IWAVE,JH,SUM,PRINT)
78         CALL FCST(NWAVE,RO,L,DEL,JI,NUMB,BUF,AMPLO,PRINT)
79         DO 19 I=1,KLAST
80     19 AAMP(I,IA)=BUF(I)
81     C
82     C
83     C
84     C ** NEXT BAMPL
85         WRITE(6,14)IA
86     14 FORMAT(' ','SPEC FROM SIN AMPLITUDES',8X,'WAVE NO',I5)
87         DO 13 I=1,NUMB
88     13 BUF(I)=BAMP(I,IA)
89         CALL SM7PT(BUF,NUMB,DATMS)
90         CALL SPEC(BUF,NUMB,DEL)
91         CALL SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)
92         IF(ABS(PRINT).GT.3.5)GO TO 9
93         CALL SPCSM(JJ,SUM,PRINT)
94     9 CALL SORT(IWAVE,JH,SUM,PRINT)
95         CALL FCST(NWAVE,RO,L,DEL,JI,NUMB,BUF,AMPLO,PRINT)
96         DO 20 I=1,KLAST
97     20 BAMP(I,IA)=BUF(I)
98     C ** CHECK TO SEE IF MAXIMUM WAVE NUMBER REACHED
99         IA=IA+1
100         IF(IA.LE.JWAVE)GO TO 16
101     25 FORMAT(I5)
102     C ** STORE NEW DATA BLOCKS
103         WRITE(14,25)KLAST
104         WRITE(15,25)KLAST
105         WRITE(16,25)KLAST
106         DO 24 I=1,KLAST

```



```

: 107      WRITE(14,23)(AAMP(I,J),J=1,JWAVE)
: 108      24 WRITE(15,23)(BAMP(I,J),J=1,JWAVE)
: 109      WRITE(16,23)(Z(J),J=1,KLAST)
: 110      C ** CHECK TO SEE IF WANT AAMPL PRINTED
: 111      IF(ABS(PRINT).LT.9.5)GO TO 26
: 112      DO 21 I=NUMB,KLAST
: 113      WRITE(6,23)(AAMP(I,J),J=1,JWAVE)
: 114      23 FORMAT(' ',11F7.3)
: 115      21 CONTINUE
: 116      26 CONTINUE
: 117      C ** FORECAST REPORTS
: 118      CALL FCDAT(JWAVE,KLAST,NUMB,PRINT)
: 119      C
: 120      C
: 121      STOP
: 122      END
: 123      C
: 124      C
: 125      C***** 7 POINT SMOOTHER *****
: 126      C      USED TO ESTIMATE MISSING DATA
: 127      C
: 128      SUBROUTINE SM7PT(BUF,NUMB,DATMS)
: 129      C ** NUMB= SIZE OF BUF (LESS THAN 400 ELEMENTS)
: 130      C ** DATMS=VALUE ASSIGNED TO MISSING DATA
: 131      DIMENSION BUF(400)
: 132      DO 1 J=1,NUMB
: 133      IF(ABS(BUF(J)-DATMS).GT.0.01)GO TO 1
: 134      SUM=0.00
: 135      M=7
: 136      DO 2 I=1,7
: 137      N=J-4+I
: 138      IF((N.LT.1).OR.(N.GT.NUMB))GO TO 3
: 139      IF(ABS(BUF(J)-DATMS).LT.0.01)GO TO 3
: 140      SUM=SUM+BUF(N)
: 141      GO TO 2
: 142      3 M=M-1
: 143      2 CONTINUE
: 144      IF(M.LE.0)GO TO 4
: 145      BUF(J)=SUM/FLOAT(M)
: 146      C ** SINCE THE MISSING DATA IS REPLACED WHEN
: 147      C      DETECTED THEN IT IS USED FOR THE NEXT
: 148      C      REPORT IF IT IS ALSO MISSING
: 149      GO TO 1
: 150      4 BUF(J)=0.00
: 151      1 CONTINUE
: 152      RETURN
: 153      END
: 154      C
: 155      C
: 156      C***** PRINT OUT DATA FROM SPECTRAL ANALYSIS ****
: 157      C
: 158      SUBROUTINE SPOUT(NUMB,RO,JH,SUM,PRINT,RMAX,JJ)
: 159      COMMON FREQ(151),R(151),Q(151),AA(151)

```



```

160 C ** NUMB=SIZE OF DIAGNOSTIC DATA SETS
161 C   RO=MEAN OF REPORT
162 C   JH=MAXIMUM NUMBER OF SPECTRAL FREQUENCIES
163 C   RMAX=SUM OF THE SPECTRAL AMPLITUDES/2
164 C   SUM=SUM OF THE MEAN SQUARES AA(I)
165 C   Q=PHASE
166 C   R=AMPLITUDE/2
167   JJ=NUMB/2 +1
168   JH=JJ-1
169   SUM=0.00
170   RMAX=0.000
171   DO 18 I=1,JH
172     RMAX=RMAX+R(I)
173   18 SUM=SUM+AA(I)
174     IF(JH.GT.40)JH=40
175     IF(PRINT.LT.0.00)GO TO 5
176     WRITE(6,16)
177   16 FORMAT(' ',10X,'FREQ',10X,'AMPL',10X,'PHASE',8X,
178     1,'MEAN SQR',8X,'POWER')
179     WRITE(6,9)FREQ(JJ),R(JJ),Q(JJ),AA(JJ)
180     DO 8 I=1,JH
181       POWER=AA(I)/SUM
182     8 WRITE(6,9)FREQ(I),R(I),Q(I),AA(I),POWER
183     9 FORMAT(' ',5F15.5)
184     5 CONTINUE
185     RO=R(JJ)
186     IF((180.00-ABS(Q(JJ))),LT.(0.10))RO=-RO
187     WRITE(6,2)SUM,RMAX
188     2 FORMAT(' ', 'VARIANCE =',F7.3,5X,'MAXIMUM AMPLITUDE'
189     1,'/2 =',F7.3)
190     RETURN
191     END
192 C
193 C***** TAKE SPECTRAL ANALYSIS OF S(N) *****
194 C
195   SUBROUTINE SPEC(S,N,DEL)
196     DIMENSION S(400),A(150),B(150)
197     COMMON FREQ(151),R(151),Q(151),AA(151)
198 C ** A(I)=COSINE COMPONENT OF WAVE NUMBER I
199 C ** B(I)=SINE COMPONENT OF WAVE NUMBER I
200 C ** N=NUMBER OF ELEMENTS IN VECTOR S (N LESS THAN 400)
201 C ** NOTE ** SQUARE OF MEAN OF S(N) STORED IN AA(L)
202   DATA TOPI/6.2831853/
203   K=N/2
204   L=N/2 + 1
205   1 FORMAT(I5)
206   2 FORMAT(' ',11F7.3)
207   V=FLOAT(L)
208   W=FLOAT(N)
209   DO 3 M=1,K
210     SUM1=0.00
211     SUM2=0.00
212     U=FLOAT(M)

```





```

213      DO 4 I=1,N
214      X=FLOAT(I)
215      D=TOPI*U*(X-V)/W
216      SUM1=SUM1+S(I)*COS(D)
217      4 SUM2=SUM2+S(I)*SIN(D)
218  C  ** CALCULATE SINE AND COSINE COMPONENTS
219      A(M)=SUM1/W
220      3 B(M)=SUM2/W
221      SUM=0.00
222      DO 5 J=1,N
223      5 SUM=SUM+S(J)
224      A(L)=SUM/W
225      SUM=0.00
226      AA(L)=A(L)*A(L)
227      SUM=SUM+AA(L)
228      R(L)=ABS(A(L))
229      DO 7 J=1,K
230  C  ** CALCULATE THE FREQUENCIES IN CYCLES PER HOUR
231      ZJ=FLOAT(J)
232      FREQ(J)=ZJ/(DEL*W)
233      R(J)=SQRT(A(J)*A(J) + B(J)*B(J))
234      IF(A(J).EQ.0.00)A(J)=0.0000001
235  C  ** CALCULATE PHASE
236      Q(J)=ATAN2(-B(J),A(J))*360./TOPI
237  C  ** CALCULATE MEAN SQUARE
238      AA(J)=R(J)*R(J)*2.
239      IF(J.EQ.K)AA(J)=AA(J)/2.
240      SUM=SUM+AA(J)
241      IF(J.GT.40)GO TO 7
242      7 CONTINUE
243      FREQ(L)=0.00
244      IF(A(L).EQ.0.000)A(L)=0.00000001
245  C  ** CALCULATE THE PHASE OF THE MEAN OF S(N)
246  C      IF Q=+,-180. THEN MEAN=-MEAN
247  C      IF Q=0. THEN MEAN HAS NO SIGN CHANGE
248      Q(L)=ATAN2(-0.00,A(L))*360./TOPI
249      RETURN
250      END
251  C
252  C***** LIST WAVES ACCORDING TO AMPLITUDE MAGNITUDE
253  C      LARGEST AMPLITUDE WAVE LISTED FIRST
254  C      SMALLEST AMPLITUDE WAVE LISTED LAST
255      SUBROUTINE SORT(IWAVE,L,SUM,PRINT)
256  C      IWAVE=NO OF FREQUENCIES
257  C  ** L=NUMBER OF FORECASTS TO BE MADE
258  C      SUM=TOTAL OF MEAN SQUARES OF WAVES
259  C      PRINT=PROGRAM PARAMETER
260  C      ITOP=ROW INDICATOR
261      COMMON FREQ(151),AMPL(151),PHASE(151),AA(151)
262      ITOP=1
263  C  ** STORE FIRST FREQUENCY
264      4 BUF=FREQ(ITOP)
265      BUA=AMPL(ITOP)

```



```

266      BUP=PHASE(ITOP)
267      BUFR=AA(ITOP)
268      ITOP=ITOP+1
269  C  ** SEARCH THROUGH ROWS
270      DO 1 J=ITOP,L
271      IF(BUA.GE.AMPL(J))GO TO 1
272  C  ** IF AMPLITUDE/2 LARGER THAN STORED WAVE THEN STORE
273  C  THIS WAVE INSTEAD AND MOVE OLD STORED WAVE TO THIS
274  C  ROW
275      STORF=FREQ(J)
276      STORA=AMPL(J)
277      STORP=PHASE(J)
278      STOPR=AA(J)
279      FREQ(J)=BUP
280      AMPL(J)=BUA
281      PHASE(J)=BUP
282      AA(J)=BUFR
283      BUP=STORF
284      BUA=STORA
285      BUP=STORP
286      BUFR=STOPR
287      1 CONTINUE
288      K=ITOP-1
289  C  ** SHIFT STORED WAVE TO PREVIOUS ROW
290      FREQ(K)=BUP
291      AMPL(K)=BUA
292      PHASE(K)=BUP
293      AA(K)=BUFR
294      IF(K.EQ.IWAVE)GO TO 6
295      IF(K.GT.L)GO TO 5
296      GO TO 4
297      5 WRITE(6,7)K
298      7 FORMAT(' ',I3,' THERE APPEARS TO BE SOME ERROR',
299      1' ITEST=',I5)
300      RETURN
301      6 CONTINUE
302  C  ** CHECK TO SEE IF WANT STRONGEST WAVES PRINTED OUT
303  C  IF PRINT GREATER THAN 0.5 THEN THEY ARE PRINTED OUT
304      IF(ABS(PRINT).LT.0.5)GO TO 3
305      WRITE(6,9)IWAVE
306      9 FORMAT(' ',I5,' STRONGEST WAVES')
307      WRITE(6,13)
308      13 FORMAT(' ',FREQ',3X',AMPL',4X',PHASE',6X',RMS')
309      3 CONTINUE
310      TOT=0.00
311  C  ** ADD UP MEAN SQUARES OF THE 6 STRONGEST WAVES
312      DO 8 J=1,IWAVE
313      IF(J.GT.6)GO TO 12
314      TOT=TOT+AA(J)
315      12 CONTINUE
316      IF(ABS(PRINT).LT.0.5)GO TO 8
317      WRITE(6,2)FREQ(J),AMPL(J),PHASE(J),AA(J)
318      2 FORMAT(' ',F7.5,F8.3,2F9.3)

```



```

319      8 CONTINUE
320      TOTAL=TOT/SUM
321      WRITE(6,10)TOTAL
322 10  FORMAT(' ', 'FOR FIRST 6 WAVES VARIANCE EXPLAINED'
323      1,F7.3)
324      RETURN
325      END
326  C
327  C*****  FORECAST TIME WAVES IN AAMPL, BAMPL,
328  C      AND DIFFERENCES  *****
329  C
330      SUBROUTINE FCST(NWAVE,RO,L,DEL,JI,NUMB,VALUE,
331      1AMPLO,PRINT)
332      DIMENSION VALUE(400),A(151)
333      COMMON FREQ(151),AMPL(151),PHASE(151),AA(151)
334      DATA PI/3.141593/
335      Q=2.*PI/360.
336      X=2.*PI*DEL
337      KLAST=NUMB+L
338      K=0
339  C  ** BY-PASS THIS LOOP IF CLIMATOLOGY FORECAST WANTED
340      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 8
341      DO 7 I=1,NWAVE
342      A(I)=2.*AMPL(I)
343      K=K+1
344  C  ** CHECK TO SEE IF THE AMPLITUDE IS LARGE ENOUGH
345  C  TO BE USE : IF AMPL LESS THAN AMPLO THEN NOT USED
346      IF(AMPL(I).LT.AMPLO)GO TO 8
347      7 CONTINUE
348      8 WRITE(6,10)K
349 10  FORMAT(' ', 'THE FIRST ',I5,'WAVES WILL BE USED')
350      JORG=1+(NUMB/2)
351  C  ** JORG=ORIGIN
352      DO 3 J=JI,KLAST
353      SUM=RO
354  C  ** CHECK FOR CLIMAT FORECAST
355      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 6
356      JN=J-JORG
357      T=FLOAT(JN)
358  C  ** ADD FORECAST WAVES TO MEAN OF AMPLITUDE
359      DO 4 I=1,K
360      SUM=SUM+A(I)*COS(X*FREQ(I)*T+Q*PHASE(I))
361      4 CONTINUE
362      6 VALUE(J)=SUM
363      3 CONTINUE
364      RETURN
365      END
366  C
367  C*****  FORECAST REPORTS  *****
368  C
369      SUBROUTINE FCDAT(JWAVE,KLAST,NUMB,PRINT)
370      DIMENSION YO(400),RO(400),S(72)
371      COMMON /NO4/Z(400),AAMP(400,11),BAMP(400,11)

```



```

319      8 CONTINUE
320      TOTAL=TOT/SUM
321      WRITE(6,10)TOTAL
322 10  FORMAT(' ', 'FOR FIRST 6 WAVES VARIANCE EXPLAINED'
323      1,F7.3)
324      RETURN
325      END
326  C
327  C*****  FORECAST TIME WAVES IN AAMPL, BAMPL,
328  C          AND DIFFERENCES  *****
329  C
330      SUBROUTINE FCST(NWAVE,RO,L,DEL,JI,NUMB,VALUE,
331      1AMPLO,PRINT)
332      DIMENSION VALUE(400),A(151)
333      COMMON FREQ(151),AMPL(151),PHASE(151),AA(151)
334      DATA PI/3.141593/
335      Q=2.*PI/360.
336      X=2.*PI*DEL
337      KLAST=NUMB+L
338      K=0
339  C  ** BY-PASS THIS LOOP IF CLIMATOLOGY FORECAST WANTED
340      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 8
341      DO 7 I=1,NWAVE
342      A(I)=2.*AMPL(I)
343      K=K+1
344  C  ** CHECK TO SEE IF THE AMPLITUDE IS LARGE ENOUGH
345  C      TO BE USE : IF AMPL LESS THAN AMPLO THEN NOT USED
346      IF(AMPL(I).LT.AMPLO)GO TO 8
347      7 CONTINUE
348      8 WRITE(6,10)K
349      10 FORMAT(' ', ' THE FIRST ',I5,'WAVES WILL BE USED')
350      JORG=1+(NUMB/2)
351  C  ** JORG=ORIGIN
352      DO 3 J=JI,KLAST
353      SUM=RO
354  C  ** CHECK FOR CLIMAT FORECAST
355      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 6
356      JN=J-JORG
357      T=FLOAT(JN)
358  C  ** ADD FORECAST WAVES TO MEAN OF AMPLITUDE
359      DO 4 I=1,K
360      SUM=SUM+A(I)*COS(X*FREQ(I)*T+Q*PHASE(I))
361      4 CONTINUE
362      6 VALUE(J)=SUM
363      3 CONTINUE
364      RETURN
365      END
366  C
367  C*****  FORECAST REPORTS  *****
368  C
369      SUBROUTINE FCDAT(JWAVE,KLAST,NUMB,PRINT)
370      DIMENSION YO(400),RO(400),S(72)
371      COMMON /NO4/Z(400),AAMP(400,11),BAMP(400,11)

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```

319      8 CONTINUE
320      TOTAL=TOT/SUM
321      WRITE(6,10)TOTAL
322 10  FORMAT(' ', 'FOR FIRST 6 WAVES VARIANCE EXPLAINED'
323      1,F7.3)
324      RETURN
325      END
326  C
327  C*****  FORECAST TIME WAVES IN AAMPL, BAMPL,
328  C      AND DIFFERENCES  *****
329  C
330      SUBROUTINE FCST(NWAVE,RO,L,DEL,JI,NUMB,VALUE,
331      1AMPLO,PRINT)
332      DIMENSION VALUE(400),A(151)
333      COMMON FREQ(151),AMPL(151),PHASE(151),AA(151)
334      DATA PI/3.141593/
335      Q=2.*PI/360.
336      X=2.*PI*DEL
337      KLAST=NUMB+L
338      K=0
339  C  ** BY-PASS THIS LOOP IF CLIMATOLOGY FORECAST WANTED
340      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 8
341      DO 7 I=1,NWAVE
342      A(I)=2.*AMPL(I)
343      K=K+1
344  C  ** CHECK TO SEE IF THE AMPLITUDE IS LARGE ENOUGH
345  C  TO BE USE : IF AMPL LESS THAN AMPLO THEN NOT USED
346      IF(AMPL(I).LT.AMPLO)GO TO 8
347      7 CONTINUE
348      8 WRITE(6,10)K
349      10 FORMAT(' ', 'THE FIRST ',I5,'WAVES WILL BE USED')
350      JORG=1+(NUMB/2)
351  C  ** JORG=ORIGIN
352      DO 3 J=JI,KLAST
353      SUM=RO
354  C  ** CHECK FOR CLIMAT FORECAST
355      IF(ABS(ABS(PRINT)-5.5).LT.0.1)GO TO 6
356      JN=J-JORG
357      T=FLOAT(JN)
358  C  ** ADD FORECAST WAVES TO MEAN OF AMPLITUDE
359      DO 4 I=1,K
360      SUM=SUM+A(I)*COS(X*FREQ(I)*T+Q*PHASE(I))
361      4 CONTINUE
362      6 VALUE(J)=SUM
363      3 CONTINUE
364      RETURN
365      END
366  C
367  C*****  FORECAST REPORTS  *****
368  C
369      SUBROUTINE FCDAT(JWAVE,KLAST,NUMB,PRINT)
370      DIMENSION YO(400),RO(400),S(72)
371      COMMON /NO4/Z(400),AAMP(400,11),BAMP(400,11)

```



```

372      DATA TOPI/6.2831853/,F1/1.3888889E-02/
373      C  ** F1=FUNDAMENTAL FREQUENCY
374      READ(9,1)KLAS1,MA
375      1 FORMAT(2I5)
376      IF(KLAST.EQ,KLAS1)GO TO 2
377      WRITE(6,3)
378      3 FORMAT(' ','TREND AND KLAST DO NOT MATCH')
379      STOP
380      C
381      C  ** GET TREND FROM STORAGE
382      2 READ(9,4)(YO(I),I=1,KLAST)
383      4 FORMAT(' ',11F7.3)
384      DO 5 I=NUMB,KLAST
385      C  ** ADD DIFFERENCES TO TREND TO GET FORECAST
386      C  MEAN OF THE REPORT
387      RO(I)=YO(I)+Z(I)
388      5 CONTINUE
389      IPRINT=IFIX(PRINT)
390      WRITE(13,1)KLAST,IPRINT
391      DO 6 I=NUMB,KLAST
392      C  ** THIS WILL PRINT OUT FORECAST MEANS OF THE REPORT
393      C  IF /PRINT/ GREATER THAN 7.5
394      IF(ABS(PRINT).LT,7.5)GO TO 12
395      WRITE(6,10)RO(I)
396      10 FORMAT(' ','RO(I)=' ,F7.3)
397      12 CONTINUE
398      C  ** USE FORECASTS OF AAMPL AND BAMPL TO
399      C  FORECAST REPORTS
400      DO 7 J=1,72
401      SUM=RO(I)
402      X=FLOAT(J-37)*F1*TOPI
403      DO 8 M=1,JWAVE
404      D=FLOAT(M)*X
405      C=COS(D)
406      SI=SIN(D)
407      SUM=SUM+2.*AAMP(I,M)*C+2.*BAMP(I,M)*SI
408      8 CONTINUE
409      S(J)=SUM
410      7 CONTINUE
411      C  ** STORE FORECAST REPORT
412      WRITE(13,9)(S(J),J=1,72)
413      9 FORMAT(' ',3(/24F4.0))
414      6 CONTINUE
415      RETURN
416      END
417      C
418      C***** SMOOTHING SPECTRUM *****
419      C (SEE CHAPTER 3 )
420      SUBROUTINE SPCSM(JJ,SUM,PRINT)
421      DIMENSION SMFH(151),SMAA(151),SMFR(151),A(151)
422      DIMENSION OLDR(151),ASQ(151),BSQ(151),AABSA(151)
422.1 DIMENSION B(151),BABSB(151)
423      COMMON FREQ(151),R(151),Q(151),AA(151)

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: 424 DATA TOP1/6.2831853/
: 425 T=TOP1/360.
: 426 JH=JJ-1
: 427 JP=JJ-2
: 428 C ** PREPARE DATA FOR USE IN SMOOTHING OPTIONS
: 429 DO 1 J=1,JH
: 430 PHASE=Q(J)*T
: 431 A(J)=R(J)*COS(PHASE)
: 432 B(J)=-R(J)*SIN(PHASE)
: 433 ASQ(J)=A(J)*A(J)
: 434 BSQ(J)=B(J)*B(J)
: 435 AABSA(J)=A(J)*ABS(A(J))
: 436 BABSB(J)=B(J)*ABS(B(J))
: 437 1 CONTINUE
: 438 C
: 439 C
: 440 C ** CHOOSE OPTION
: 441 IF(ABS(ABS(PRINT)-3.0).LT.0.1)GO TO 300
: 442 IF(ABS(ABS(PRINT)-2.0).LT.0.1)GO TO 200
: 443 IF(ABS(ABS(PRINT)-1.0).LT.0.1)GO TO 100
: 444 WRITE(6,2)
: 445 2 FORMAT(' ','***NO SMOOTHING OPTION USED ***')
: 446 RETURN
: 447 C
: 448 C
: 449 C
: 450 300 WRITE(6,301)
: 451 301 FORMAT(' ',' SMOOTHING OPTION NUMBER 3 USED')
: 452 AR=(AABSA(1)+AABSA(2))/2.
: 453 BR=(BABSB(1)+BABSB(2))/2.
: 454 SMPH(1)=ATAN2(-BR,AR)/T
: 455 SMAA(1)=ABS(AR)+ABS(BR)
: 456 SMFR(1)=(FREQ(1)*AA(1)+FREQ(2)*AA(2))/(AA(1)+AA(2))
: 457 DO 302 J=2,JP
: 458 AR=(AABSA(J-1)+AABSA(J)+AABSA(J+1))/3.
: 459 BR=(BABSB(J-1)+BABSB(J)+BABSB(J+1))/3.
: 460 SMPH(J)=ATAN2(-BR,AR)/T
: 461 SMAA(J)=(ABS(AR)+ABS(BR))*2./3.
: 462 SMFR(J)=(FREQ(J-1)*AA(J-1)+FREQ(J)*AA(J)+FREQ(J+1)*
: 463 1AA(J+1))/(AA(J-1)+AA(J)+AA(J+1))
: 464 302 CONTINUE
: 465 SMAA(JH)=AA(JH)
: 466 SMFR(JH)=FREQ(JH)
: 467 SMPH(JH)=Q(JH)
: 468 GO TO 500
: 469 C
: 470 C
: 471 C
: 472 200 WRITE(6,201)
: 473 201 FORMAT(' ',' SMOOTHING OPTION NUMBER 2 USED')
: 474 AR=(A(1)+A(2))/2.
: 475 BR=(B(1)+B(2))/2.
: 476 SMPH(1)=ATAN2(-BR,AR)/T

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477      SMAA(1)=AA(1)+AA(2)
478      SMFR(1)=(FREQ(1)*AA(1)+FREQ(2)*AA(2))/SMAA(1)
479      SMAA(1)=SMAA(1)/2.
480      DO 202 J=2,JF
481      AR=(A(J-1)+A(J)+A(J+1))/3.
482      BR=(B(J-1)+B(J)+B(J+1))/3.
483      SMPH(J)=ATAN2(-BR,AR)/T
484      SMAA(J)=AA(J-1)+AA(J)+AA(J+1)
485      SMFR(J)=(FREQ(J-1)*AA(J-1)+FREQ(J)*AA(J)+FREQ(J+1)*
486      2AA(J+1))/SMAA(J)
487      SMAA(J)=SMAA(J)/3.
488      202 CONTINUE
489      SMAA(JH)=AA(JH)
490      SMFR(JH)=FREQ(JH)
491      SMPH(JH)=Q(JH)
492      GO TO 500
493      C
494      C
495      C
496      100 WRITE(6,101)
497      101 FORMAT(' ',' SMOOTHING OPTION NUMBER 1 USED')
498      AR=(A(1)+A(2))/2.
499      BR=(B(1)+B(2))/2.
500      SMAA(1)=(AR*AR+BR*BR)*2.
501      SMFR(1)=(FREQ(1)*AA(1)+FREQ(2)*AA(2))/(AA(1)+AA(2))
502      SMPH(1)=ATAN2(-BR,AR)/T
503      DO 102 J=2,JF
504      AR=(A(J-1)+A(J)+A(J+1))/3.
505      BR=(B(J-1)+B(J)+B(J+1))/3.
506      SMPH(J)=ATAN2(-BR,AR)/T
507      SMAA(J)=(AR*AR+BR*BR)*2.
508      SMFR(J)=(FREQ(J-1)*AA(J-1)+FREQ(J)*AA(J)+FREQ(J+1)*
509      3AA(J+1))/(AA(J-1)+AA(J)+AA(J+1))
510      102 CONTINUE
511      SMAA(JH)=AA(JH)
512      SMAA(JH)=AA(JH)
513      SMFR(JH)=FREQ(JH)
514      SMPH(JH)=Q(JH)
515      C
516      C
517      C
518      500 CONTINUE
519      SRMAX=0.00
520      C  ** MOVE SMOOTHED DATA TO COMMON BLOCK ELEMENTS
521      DO 501 I=1,JH
522      AA(I)=SMAA(I)
523      OLDR(I)=SQRT(SMAA(I)/2.)
524      SRMAX=SRMAX+AA(I)
525      Q(I)=SMPH(I)
526      FREQ(I)=SMFR(I)
527      501 CONTINUE
528      WRITE(6,502)
529      502 FORMAT(' ',10X,'FREQ',10X,'AMP',12X,'OLD R',8X,

```





```
: 530      4'PHASE',8X,'SMOOTH MEAN SQ')
: 531      IF(SRMAX.LT.0.0001)SRMAX=0.0001
: 532 C  ** SMOOTHING FINISHED--- DO VARIANCE ADJUST
: 533      DO 503 I=1,JH
: 534      AA(I)=SUM*AA(I)/SRMAX
: 535      R(I)=SQRT(AA(I)/2.)
: 536      IF(I.GT.40)GO TO 503
: 537      WRITE(6,504)FREQ(I),R(I),OLDR(I),Q(I),AA(I)
: 538      504 FORMAT(' ',5F15.5)
: 539      503 CONTINUE
: 540      WRITE(6,505)SRMAX
: 541      505 FORMAT(' ', 'TOTAL SMOOTH AMPLITUDE SQUARED * 2 =',
: 541.5      1F7.3)
: 542      RETURN
: 543      END
:
```



## APPENDIX I

### PROGRAM PARAMETERS

IWAVE = number of strong waves that are to be listed.  
These waves have been sorted according to the  
magnitude of the amplitude.

PRINT = parameter that determines smoothing option to  
be used (see below description).

L = number of forecasts to be made.

DIV(=JWAVE) = number of space-waves used to forecast  
heights.

NWAVE = number of time-waves used to forecast amplitudes  
for space-waves.

NUM = NUMB = number of elements in the diagnostic data  
sets.

RMS =  $(\text{Variance})^{\frac{1}{2}}$ . The variance of differences from the  
trend

JI = starting point of diagnostic data sets

#### Values for PRINT Parameter

If print is negative, then the unsmoothed spectrum  
is not listed.

#### Absolute Value of PRINT

LT 0.5: no smoothing option used plus sorted strong  
waves not printed out.

= 1.0  $\pm$  0.1: smoothing option No. 1 used.



= 2.0  $\pm$ 0.1: smoothing option No. 2 used.

= 3.0  $\pm$ 0.1: smoothing option No. 3 used.

GT 3.5: no smoothing option chosen, therefore, bypass  
smoothing subroutine SPCSM

= 4.0: persistence forecast made (see verification  
program listing in Appendix I)

= 5.5: climatology forecast made  
note space-wave pattern is constant but  
means still adjusted for trend

= 6.0: value that can be used when verification  
program also used.

GE 7.5: print out forecast means

GT 9.5: print out estimated AAMPL for forecast period

LT = less than

GT = greater than

GE = greater than or equal to.



## APPENDIX J

### LISTING OF VERIFICATION PROGRAM

#### Files Needed for Input

##### Number

- |    |                                                      |
|----|------------------------------------------------------|
| 13 | -Forecast height reports from Part 2 of the program. |
| 5  | -Actual height reports.                              |

Note: Persistence forecasts are generated by lines 42 to 47.





```

1      C
2      C
3      C *** VERIFICATION PROGRAM ***
4      C*****
5      C
6      C
7          DIMENSION S(72),Y(72),D(72),A(72),R(60),RMSEE(60)
8          INTEGER HOV(60,72),FHOV(60,72)
9          READ(13,1)KLAST,IPRINT
10         1 FORMAT(2I5)
11         TOTAL=28.0
12         DO 2 I=1,60
13             NOZO=0
14             IO=I-1
15             TIME=FLOAT(IO)/2.
16             WRITE(6,78)IO,TIME
17         78 FORMAT('0','FORECAST',I5,'=',5X,'TO+',F5.1,' DAYS')
18         READ(13,9)(S(J),J=1,72)
19         9 FORMAT(' ',3(/24F4.0))
20         READ(5,8)(Y(J),J=1,72)
21         8 FORMAT(2(24F3.0,8X/),24F3.0)
22     C ** SET UP HOVMOLLER DIAGRAMS
23     C     HOV= ACTUAL HEIGHTS
24     C     FHOV=FORECAST HEIGHTS
25         DO 15 L=1,72
26             HOV(I,L)=IFIX(Y(L))
27             FHOV(I,L)=IFIX(S(L))
28             IF(Y(L).EQ.0.00)NOZO=NOZO+1
29             IF(I.GT.1)GO TO 15
30             A(L)=Y(L)
31         15 CONTINUE
32     C ** CHECK FOR MISSING DATA
33         IF(NOZO.LT.35)GO TO 16
34         WRITE(6,17)NOZO
35         17 FORMAT(' ',' DATA MISSING  NO ZEROS=',I5)
36         R(I)=99.99
37         RMSEE(I)=-9.99
38         TOTAL=TOTAL-1.
39         GO TO 2
40     C
41     C
42     C ** CHECK TO SEE IF PERSISTENCE FORECAST WANTED
43         16 IF(IPRINT.NE.4)GO TO 21
44             DO 21 J=1,72
45                 S(J)=A(J)
46                 FHOV(I,J)=IFIX(S(J))
47         21 CONTINUE
48     C ** PRINT HEIGHTS
49         WRITE(6,19)
50         19 FORMAT(' ',' FORECAST REPORT = S(L)')
51         WRITE(6,77)(S(J),J=1,72)
52         77 FORMAT(' ',3(24F4.0/,1X))

```



```

53      WRITE(6,18)
54      18 FORMAT(' ', ' ACTUAL REPORT = Y(L)')
55      WRITE(6,77)(Y(J),J=1,72)
56      C
57      C *** CALCULATE STATISTICS FOR THIS FORECAST
58      C      AND ACTUAL HEIGHT DATA AT THIS TIME
59      COF=99.
60      SO=0.00
61      SMAG=0.00
62      YMAG=0.00
63      SDOTY=0.00
64      SUM2=0.00
65      SUM1=0.00
66      SUM=0.00
67      DO 3 K=1,72
68      D(K)=S(K)-Y(K)
69      SUM=SUM+ABS(D(K))
70      SUM1=SUM1+D(K)*D(K)
71      SUM2=SUM2+D(K)
72      SO=S(K)+SO
73      SDOTY=S(K)*Y(K) + SDOTY
74      YMAG=Y(K)*Y(K) + YMAG
75      SMAG=S(K)*S(K) + SMAG
76      3 CONTINUE
77      C
78      C
79      C
80      SMAD=SUM/72.
81      DMEAN=SUM2/72.
82      SMSE=SUM1/72.
83      SMYM=YMAG*SMAG
84      IF(SMYM.LT.0.0001)GO TO 11
85      COF=SDOTY/SQRT(SMYM)
86      11 SO=SO/72.
87      WRITE(6,12)COF,SO
88      12 FORMAT(' ', 'COF=',F7.3,5X,'SO=',F7.3)
89      WRITE(6,4)SMAD,DMEAN,SMSE
90      4 FORMAT(' ', ' MEAN ABSOLUTE DIFFERENCE=',F7.3,3X,
91      1'MEAN DIFFERENCE=',F7.3,3X,'MEAN SQUARE ERROR '
92      2,'ESTIMATE=',F7.3)
93      RMSEE(I)=SMSE
94      YO=SO-DMEAN
95      SY=SQRT(YMAG/72.-YO*YO)
96      SS=SQRT(SMAG/72.-SO*SO)
97      RCOF=(SDOTY-72.*SO*YO)/(72.*SY*SS)
98      R(I)=RCOF
99      WRITE(6,13)YO,SY,SS,RCOF
100     13 FORMAT(' ', 'YO=',F7.3,5X,'SY=',F7.3,5X,'SS=',F7.3,
101     35X,'R=',F7.3)
102     2 CONTINUE
103     C      (CONTINUED ON NEXT PAGE)
104     C

```



```

105 C
106 C **** PRINT OUT FIRST 28 FORECAST VALUES
107 C     FOR R,MSEE,AVERAGE R, AND AVERAGE MSEE
108     WRITE(6,24)
109     SUM=0.00
110     SUM2=0.00
111     IO=0
112     WRITE(6,23)IO,R(1),RMSEE(1)
113     DO 22 I=2,29
114     IO=I-1
115     WRITE(6,23)IO,R(I),RMSEE(I)
116 23  FORMAT(' ',I5,F7.3,F7.1)
117     IF(ABS(R(I)-99.99).LT.1.00)GO TO 22
118     SUM=SUM+R(I)
119     SUM2=SUM2+RMSEE(I)
120 22  CONTINUE
121 24  FORMAT('1',3X,'I',5X,'R',5X,'MSEE')
122     SUM=SUM/TOTAL
123     SUM2=SUM2/TOTAL
124     WRITE(6,25)SUM,SUM2
125 25  FORMAT(' ','MEANS',F7.3,F7.1)
126 C
127 C
128 C **** PRINT OUT HOVMOLLER DIAGRAMS ***
129 C
130 C     ACTUAL DATA
131     IF((IPRINT*IPRINT).LT.9)GO TO 30
132     WRITE(6,28)
133 28  FORMAT('1','PART 1')
134     DO 26 I=1,28
135     WRITE(6,27)(HOV(I,J),J=1,36)
136 27  FORMAT(' ',36I3)
137 26  CONTINUE
138     WRITE(6,29)
139 29  FORMAT('1','PART 2')
140     DO 30 I=1,28
141     WRITE(6,27)(HOV(I,J),J=37,72)
142 30  CONTINUE
143 C **  FORECAST DATA
144     WRITE(6,28)
145     DO 31 I=1,28
146     WRITE(6,27)(FHOV(I,J),J=1,36)
147 31  CONTINUE
148     WRITE(6,29)
149     DO 32 I=1,28
150     WRITE(6,27)(FHOV(I,J),J=37,72)
151 32  CONTINUE
152     STOP
153     END

```



## APPENDIX K

### TEST DATA PROGRAM





```

C***** PROGRAM TO GENERATE TEST DATA ****
C
C      S=GENERATED HEIGHT REPORT
C      A=COSINE COMPONENT OF WAVE AMPLITUDE
C      B=SINE COMPONENT OF WAVE AMPLITUDE
C      F,C=AMPLITUDE/2 OF THE SPACE WAVE
C      Q,CQ=THE CORRESPONDING PHASE
C
C      DIMENSION RO(400),S(72),A(11),B(11),C(11),Q(11),
1F(11),CQ(11)
C      INTEGER T
C      DATA TOPI/6.28318/
C      F=TOPI/730.
C  ** TREND COEFFICIENTS INATIALIZED
C      ROM=51.0
C      G=-4.0
C      H=-11.0
C      Z=TOPI/360.
C      NUMB=90
C  ** THE LENGTH OF THE LONGEST WAVE
C      CUMB=FLOAT(NUMB)-60.
C  ** U IS USED TO DETERMINE THE ORIGIN
C      U=CUMB/2.+1.
C      WRITE(7,13)NUMB
C      WRITE(8,13)NUMB
C      WRITE(9,13)NUMB
13  FORMAT(I5)
C
C
C  ** GENERATE THE TREND
C      DO 1 T=1,NUMB
C      RO(T)=ROM+G*COS(P*T) + H*SIN(P*T)
C      X=(T-U)/CUMB
C
C
C  ** GENERATE SPACE WAVES
C      DO 2 M=1,11
C      V=FLOAT(M)
C  ** SET MEAN VALUES FOR A(M),B(M)
C      ROMB=1.5/V
C      ROMA=-0.8/V
C      SUM2=ROMB
C      SUM1=ROMA
C  ** ADD TIME WAVES TO SPACE WAVE AMPLITUDES
C      DO 3 I=1,11
C      W=FLOAT(I)
C  ** SET SPACE WAVES=0.00
C      C(I)=0.00
C      F(I)=0.00
C      Q(I)=0.00

```



```

      CQ(I)=0.00
C  ** PICK WHICH WAVES WILL BE NON-ZERO
      IF(I.EQ.M)GO TO 5
      IF(I.EQ.(2*M))GO TO 5
      IF(I.EQ.(3*M))GO TO 5
      GO TO 4
C  ** SET THE VALUE OF THE NON-ZERO COMPONENTS
      5 F(I)=0.9/W
      Q(I)=40.*W*Z
      CQ(I)=-10.*W*Z
      C(I)=0.7-0.03*V
      4 CONTINUE
      E=TOPI*X*W
C  ** CALCULATE THE SPACE WAVE COMPONENTS A(M),B(M)
      SUM2=SUM2+2.*F(I)*COS(E+Q(I))
      SUM1=SUM1+2.*C(I)*COS(E+CQ(I))
      3 CONTINUE
      A(M)=SUM1
      B(M)=SUM2
      2 CONTINUE
      WRITE(7,12)(A(J),J=1,11)
      WRITE(8,12)(B(J),J=1,11)
      12 FORMAT(11F7.2)
C
C
C  ** COMBINE TREND AND SPACE WAVES TO GET REPORT
      DO 7 L=1,72
      SUM3=RO(T)
      D=TOPI*FLOAT(L-37)/72.
      DO 6 M=1,11
      DM=D*FLOAT(M)
      SUM3=SUM3+2.*A(M)*COS(DM)+2.*B(M)*SIN(DM)
      6 CONTINUE
      S(L)=SUM3
      7 CONTINUE
C  ** STORE THE REPORT
      WRITE(10,15)(S(L),L=1,24),T,T
      WRITE(10,16)(S(L),L=25,48),T
      WRITE(10,17)(S(L),L=49,72),RO(T),X
      15 FORMAT(24F3.0,2I4)
      16 FORMAT(24F3.0,I4)
      17 FORMAT(24F3.0,2F4.1)
C
C
      1 CONTINUE
C  ** STORE THE TREND
      WRITE(9,14)(RO(T),T=1,NUMB)
      14 FORMAT(' ',11F7.3)
      STOP
      END

```



## APPENDIX L

Table L.1: Results using other various techniques for smoothing. (Used on test sample)

Method:

1. Smoother Option No. 2 with variance adjustment.
2. Smoother Option No. 2 with no variance adjustment
3. Smoother Option No. 2 with no variance adjustment and the smooth mean square of the time-wave with wave number 1 calculated by  $(0 + AA(1) + AA(2)) / 3$ .
4. Same as method 2, except the frequency is not smoothed (i.e. not weighted)
5. Same as method 1, except the time-wave with wave number 1 is not smoothed.
6. Same as method 4 except the time-wave with wave number 1 is not smoothed.

The value "r" in this Appendix is the correlation coefficient (i.e.  $r = R$ ).



Table L.1. Results Using Other Various Techniques for Smoothing

| Forecast No. | Method 1<br>r<br>MSEE | Method 2<br>r<br>MSEE | Method 3<br>r<br>MSEE | Method 4<br>r<br>MSEE | Method 5<br>r<br>MSEE | Method 6<br>r<br>MSEE |
|--------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 0            | 0.674                 | 0.655                 | 0.622                 | 0.516                 | 0.515                 | 0.506                 |
| 1            | 0.517                 | 0.478                 | 0.451                 | 0.453                 | 0.363                 | 0.410                 |
| 2            | 0.565                 | 0.558                 | 0.535                 | -0.031                | 0.411                 | -0.057                |
| 3            | 0.833                 | 0.830                 | 0.819                 | -0.112                | 0.708                 | -0.151                |
| 4            | 0.183                 | 0.170                 | 0.117                 | 0.174                 | 0.005                 | 0.109                 |
| 5            | 0.708                 | 0.695                 | 0.685                 | 0.132                 | 0.599                 | 0.096                 |
| 6            | 0.632                 | 0.656                 | 0.650                 | 0.370                 | 0.549                 | 0.345                 |
| 7            | 0.585                 | 0.563                 | 0.572                 | 0.558                 | 0.561                 | 0.559                 |
| 8            | 0.788                 | 0.786                 | 0.793                 | 0.678                 | 0.686                 | 0.695                 |
| 9            | 0.651                 | 0.624                 | 0.627                 | 0.693                 | 0.582                 | 0.710                 |
| 10           | 0.908                 | 0.899                 | 0.895                 | 0.633                 | 0.799                 | 0.655                 |
| 11           | 0.594                 | 0.569                 | 0.569                 | 0.435                 | 0.479                 | 0.471                 |
| 12           | 0.756                 | 0.746                 | 0.750                 | 0.320                 | 0.630                 | 0.324                 |
| 13           | 0.880                 | 0.882                 | 0.879                 | 0.250                 | 0.808                 | 0.257                 |
| 14           | 0.856                 | 0.858                 | 0.859                 | 0.396                 | 0.725                 | 0.409                 |
| 15           | 0.763                 | 0.758                 | 0.752                 | 0.231                 | 0.598                 | 0.233                 |
| 16           | 0.195                 | 0.121                 | 0.097                 | -0.253                | -0.023                | -0.268                |
| 17           | 0.588                 | 0.586                 | 0.577                 | 0.107                 | 0.418                 | 0.100                 |
| 18           | 0.815                 | 0.841                 | 0.818                 | 0.194                 | 0.582                 | 0.170                 |
| 19           | 0.346                 | 0.304                 | 0.290                 | -0.052                | 0.163                 | -0.067                |
| MEAN         | 0.642                 | 0.629                 | 0.619                 | 0.285                 | 0.508                 | 0.275                 |
|              |                       | 37                    | 38                    | 65                    | 44                    | 67                    |





## APPENDIX M

### Actual Forecasts Results (Southern Data Set)

Table M.1.

Results Using the Southern Data Set NUMB = 90  
and JWAVE = 8.

Table M.2.

Results Using the Southern Data Set NUMB = 240

The value "r" in this Appendix is the correlation coefficient (i.e.  $r = R$ ).

NOTE: Forecast numbers are listed to the left of these tables. Forecast number = 0 is for the last diagnostic report and is not considered in the Mean at the bottom of the table.



Table M.1. Results Using Southern Data Set

| Table M.1. | Results Using Southern Data Set |    |      |       |   |             |       |      |  |       | NUMB = 90<br>JWAVE = 8 |  |       |    |  |                              |     |      |       |    | Part a |                     |     |      |       |    |                              |       |      |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |
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|            | Climatology                     |    |      |       |   | Persistence |       |      |  |       | Unsmooth<br>NWAVE=1    |  |       |    |  | Smoother<br>No. 2<br>NWAVE=1 |     |      |       |    |        | Unsmooth<br>NWAVE=2 |     |      |       |    | Smoother<br>No. 2<br>NWAVE=2 |       |      |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |      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|       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |
|            | r                               |    | MSEE |       |   | r           |       | MSEE |  |       | r                      |  | MSEE  |    |  | r                            |     | MSEE |       |    |        | r                   |     | MSEE |       |    | r                            |       | MSEE |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |      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|       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |       |     |  |       |    |  |
| 0          | 0.907                           | 72 |      | 1.000 | 0 |             | 0.866 | 72   |  | 0.798 | 102                    |  | 0.933 | 39 |  | 0.798                        | 102 |      | 0.933 | 39 |        | 0.798               | 102 |      | 0.933 | 39 |                              | 0.798 | 102  |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  | 0.798 | 102 |  | 0.933 | 39 |  |



Table M.1. Part a, cont'

|      |       |    |       |     |       |     |       |    |       |     |       |     |
|------|-------|----|-------|-----|-------|-----|-------|----|-------|-----|-------|-----|
| 26   | 0.817 | 63 | 0.806 | 104 | 0.612 | 91  | 0.797 | 70 | 0.330 | 150 | 0.762 | 108 |
| 27   | 0.750 | 80 | 0.763 | 121 | 0.533 | 104 | 0.757 | 84 | 0.267 | 158 | 0.702 | 132 |
| 28   | 0.736 | 86 | 0.749 | 131 | 0.523 | 104 | 0.777 | 85 | 0.282 | 151 | 0.714 | 136 |
| MEAN | 0.798 | 64 | 0.803 | 95  | 0.655 | 92  | 0.742 | 78 | 0.530 | 116 | 0.635 | 112 |



Table M.1. Results Using Southern Data Set

|    | NUMB = 90             |      |                             |      | NUMB = 8                     |      |                         |      | Part b                       |      |                         |      |
|----|-----------------------|------|-----------------------------|------|------------------------------|------|-------------------------|------|------------------------------|------|-------------------------|------|
|    | Unsmoothed<br>NWAVE=3 |      | Smoother<br>No. 2<br>NWAVE3 |      | Smoother<br>No. 3<br>NWAVE=3 |      | Unsmoothed<br>NWAVE = 4 |      | Smoother<br>No. 2<br>NWAVE=4 |      | Unsmoothed<br>NWAVE = 5 |      |
|    | r                     | MSEE | r                           | MSEE | r                            | MSEE | r                       | MSEE | r                            | MSEE | r                       | MSEE |
| 0  | 0.952                 | 39   | 0.632                       | 151  | 0.610                        | 158  | 0.949                   | 37   | 0.661                        | 142  | 0.951                   | 34   |
| 1  | 0.886                 | 56   | 0.518                       | 174  | 0.480                        | 184  | 0.879                   | 58   | 0.579                        | 154  | 0.879                   | 36   |
| 2  | 0.883                 | 54   | 0.533                       | 162  | 0.478                        | 176  | 0.856                   | 63   | 0.600                        | 142  | 0.854                   | 62   |
| 3  | 0.827                 | 63   | 0.538                       | 142  | 0.472                        | 158  | 0.788                   | 75   | 0.625                        | 119  | 0.785                   | 76   |
| 4  | 0.757                 | 78   | 0.561                       | 126  | 0.476                        | 147  | 0.710                   | 92   | 0.641                        | 107  | 0.707                   | 95   |
| 5  | 0.690                 | 96   | 0.526                       | 130  | 0.465                        | 146  | 0.631                   | 114  | 0.582                        | 117  | 0.642                   | 111  |
| 6  | 0.592                 | 123  | 0.518                       | 131  | 0.431                        | 151  | 0.550                   | 138  | 0.530                        | 128  | 0.552                   | 135  |
| 7  | 0.494                 | 149  | 0.514                       | 131  | 0.415                        | 155  | 0.470                   | 158  | 0.483                        | 137  | 0.477                   | 152  |
| 8  | 0.524                 | 139  | 0.514                       | 128  | 0.407                        | 152  | 0.536                   | 138  | 0.448                        | 142  | 0.545                   | 131  |
| 9  | 0.525                 | 130  | 0.520                       | 117  | 0.399                        | 144  | 0.564                   | 121  | 0.450                        | 132  | 0.552                   | 122  |
| 10 | 0.536                 | 123  | 0.551                       | 107  | 0.435                        | 132  | 0.581                   | 112  | 0.473                        | 123  | 0.574                   | 113  |
| 11 | 0.534                 | 109  | 0.518                       | 101  | 0.429                        | 120  | 0.556                   | 105  | 0.435                        | 118  | 0.531                   | 112  |
| 12 | 0.594                 | 89   | 0.730                       | 57   | 0.604                        | 79   | 0.632                   | 80   | 0.687                        | 64   | 0.603                   | 89   |
| 13 | 0.606                 | 82   | 0.787                       | 44   | 0.665                        | 66   | 0.644                   | 75   | 0.766                        | 48   | 0.622                   | 83   |
| 14 | 0.578                 | 99   | 0.810                       | 49   | 0.731                        | 65   | 0.611                   | 90   | 0.820                        | 48   | 0.582                   | 99   |
| 15 | 0.546                 | 108  | 0.785                       | 55   | 0.750                        | 66   | 0.574                   | 100  | 0.823                        | 51   | 0.537                   | 114  |
| 16 | 0.574                 | 99   | 0.765                       | 58   | 0.772                        | 79   | 0.583                   | 96   | 0.809                        | 52   | 0.551                   | 108  |
| 17 | 0.577                 | 99   | 0.770                       | 58   | 0.830                        | 49   | 0.564                   | 99   | 0.810                        | 51   | 0.536                   | 111  |
| 18 | 0.514                 | 108  | 0.781                       | 54   | 0.850                        | 42   | 0.477                   | 114  | 0.799                        | 51   | 0.446                   | 127  |
| 19 | 0.405                 | 151  | 0.729                       | 80   | 0.803                        | 63   | 0.327                   | 170  | 0.744                        | 76   | 0.310                   | 183  |
| 20 | 0.358                 | 177  | 0.703                       | 96   | 0.731                        | 87   | 0.257                   | 209  | 0.700                        | 97   | 0.259                   | 220  |
| 21 | 0.307                 | 192  | 0.670                       | 110  | 0.655                        | 108  | 0.233                   | 225  | 0.654                        | 113  | 0.238                   | 234  |
| 22 | 0.270                 | 185  | 0.612                       | 122  | 0.533                        | 131  | 0.228                   | 215  | 0.578                        | 129  | 0.237                   | 221  |
| 23 | 0.354                 | 156  | 0.629                       | 118  | 0.544                        | 128  | 0.326                   | 180  | 0.607                        | 125  | 0.331                   | 185  |
| 24 | 0.366                 | 146  | 0.642                       | 120  | 0.526                        | 134  | 0.341                   | 165  | 0.619                        | 130  | 0.361                   | 166  |
| 25 | 0.291                 | 156  | 0.679                       | 123  | 0.597                        | 128  | 0.258                   | 174  | 0.666                        | 134  | 0.281                   | 177  |
| 26 | 0.268                 | 168  | 0.694                       | 129  | 0.586                        | 146  | 0.253                   | 178  | 0.668                        | 148  | 0.303                   | 179  |









Table M.1. Results Using Southern Data Set NUMB = 90 Part c  
JWAVE = 8

|    | Unsmooth<br>NWAVE=6 |      | Smoother<br>No. 1<br>NWAVE=6 |      | Smoother<br>No. 2<br>NWAVE=6 |      | Smoother<br>No. 3<br>NWAVE=6 |      | Smoother<br>No. 2<br>NWAVE=11 |      | Unsmooth<br>NWAVE=11 |      |
|----|---------------------|------|------------------------------|------|------------------------------|------|------------------------------|------|-------------------------------|------|----------------------|------|
|    | r                   | MSEE | r                            | MSEE | r                            | MSEE | r                            | MSEE | r                             | MSEE | r                    | MSEE |
| 0  | 0.958               | 29   | 0.541                        | 178  | 0.611                        | 180  | 0.559                        | 175  | 0.541                         | 178  | 0.952                | 31   |
| 1  | 0.876               | 57   | 0.445                        | 191  | 0.537                        | 165  | 0.467                        | 189  | 0.488                         | 180  | 0.829                | 74   |
| 2  | 0.841               | 66   | 0.474                        | 177  | 0.592                        | 144  | 0.514                        | 168  | 0.576                         | 149  | 0.768                | 91   |
| 3  | 0.763               | 83   | 0.473                        | 158  | 0.618                        | 122  | 0.530                        | 146  | 0.620                         | 121  | 0.703                | 101  |
| 4  | 0.680               | 102  | 0.470                        | 149  | 0.605                        | 118  | 0.517                        | 140  | 0.611                         | 117  | 0.663                | 106  |
| 5  | 0.613               | 120  | 0.438                        | 153  | 0.554                        | 131  | 0.471                        | 149  | 0.559                         | 130  | 0.642                | 112  |
| 6  | 0.515               | 145  | 0.386                        | 164  | 0.509                        | 144  | 0.404                        | 164  | 0.592                         | 149  | 0.569                | 135  |
| 7  | 0.424               | 166  | 0.398                        | 159  | 0.514                        | 141  | 0.373                        | 170  | 0.482                         | 151  | 0.513                | 149  |
| 8  | 0.516               | 138  | 0.330                        | 171  | 0.504                        | 141  | 0.339                        | 175  | 0.447                         | 157  | 0.584                | 125  |
| 9  | 0.549               | 122  | 0.310                        | 166  | 0.514                        | 129  | 0.318                        | 169  | 0.454                         | 146  | 0.587                | 114  |
| 10 | 0.593               | 111  | 0.335                        | 156  | 0.497                        | 126  | 0.319                        | 161  | 0.455                         | 140  | 0.582                | 111  |
| 11 | 0.573               | 108  | 0.294                        | 150  | 0.388                        | 133  | 0.239                        | 159  | 0.361                         | 144  | 0.512                | 120  |
| 12 | 0.659               | 88   | 0.518                        | 98   | 0.601                        | 77   | 0.478                        | 96   | 0.556                         | 94   | 0.617                | 92   |
| 13 | 0.680               | 81   | 0.594                        | 84   | 0.662                        | 62   | 0.573                        | 75   | 0.641                         | 74   | 0.657                | 85   |
| 14 | 0.635               | 96   | 0.726                        | 71   | 0.699                        | 65   | 0.673                        | 71   | 0.704                         | 74   | 0.635                | 98   |
| 15 | 0.576               | 109  | 0.776                        | 63   | 0.675                        | 74   | 0.682                        | 75   | 0.706                         | 78   | 0.603                | 105  |
| 16 | 0.552               | 109  | 0.792                        | 51   | 0.641                        | 81   | 0.701                        | 71   | 0.690                         | 79   | 0.587                | 103  |
| 17 | 0.496               | 119  | 0.852                        | 41   | 0.677                        | 75   | 0.740                        | 62   | 0.733                         | 69   | 0.515                | 118  |
| 18 | 0.368               | 145  | 0.863                        | 38   | 0.716                        | 67   | 0.746                        | 58   | 0.763                         | 57   | 0.349                | 155  |
| 19 | 0.231               | 205  | 0.822                        | 60   | 0.712                        | 85   | 0.712                        | 79   | 0.724                         | 77   | 0.204                | 217  |
| 20 | 0.194               | 238  | 0.762                        | 92   | 0.678                        | 105  | 0.669                        | 102  | 0.683                         | 96   | 0.171                | 247  |
| 21 | 0.204               | 242  | 0.693                        | 129  | 0.638                        | 123  | 0.620                        | 124  | 0.636                         | 119  | 0.190                | 245  |
| 22 | 0.207               | 220  | 0.581                        | 161  | 0.563                        | 145  | 0.522                        | 154  | 0.571                         | 144  | 0.230                | 213  |
| 23 | 0.309               | 181  | 0.558                        | 169  | 0.617                        | 139  | 0.568                        | 147  | 0.610                         | 143  | 0.355                | 169  |
| 24 | 0.339               | 168  | 0.556                        | 164  | 0.629                        | 151  | 0.562                        | 158  | 0.625                         | 151  | 0.374                | 158  |



Table M.I.      Part c   cont'

|      |       |     |       |     |       |     |       |     |       |     |       |     |
|------|-------|-----|-------|-----|-------|-----|-------|-----|-------|-----|-------|-----|
| 25   | 0.256 | 184 | 0.623 | 143 | 0.649 | 168 | 0.602 | 160 | 0.661 | 155 | 0.275 | 180 |
| 26   | 0.291 | 186 | 0.602 | 151 | 0.640 | 184 | 0.575 | 176 | 0.644 | 168 | 0.273 | 193 |
| 27   | 0.235 | 200 | 0.535 | 179 | 0.581 | 212 | 0.527 | 199 | 0.588 | 196 | 0.192 | 215 |
| 28   | 0.302 | 182 | 0.526 | 200 | 0.601 | 211 | 0.531 | 204 | 0.593 | 206 | 0.250 | 199 |
| MEAN | 0.482 | 142 | 0.561 | 132 | 0.601 | 126 | 0.535 | 136 | 0.595 | 127 | 0.480 | 144 |



Table M.2.

Results Using Southern Data Set

NUMB = 240  
JWAVE = 8

Part a

## Climatology

## Persistence

Unsmooth  
NWAVE=1Smoother  
No. 1  
NWAVE=1Smoother  
No. 2  
NWAVE=1Smoother  
No. 3  
NWAVE=1

|    | r     | MSEE | r      | MSEE | r     | MSEE | r     | MSEE | r     | MSEE | r     | MSEE |
|----|-------|------|--------|------|-------|------|-------|------|-------|------|-------|------|
| 0  | 0.565 | 72   | 1.000  | 0    | 0.696 | 49   | 0.678 | 53   | 0.552 | 74   | 0.654 | 59   |
| 1  | 0.599 | 74   | 0.943  | 12   | 0.714 | 53   | 0.685 | 62   | 0.576 | 78   | 0.672 | 64   |
| 2  | 0.697 | 70   | 0.830  | 40   | 0.772 | 59   | 0.725 | 71   | 0.671 | 77   | 0.749 | 65   |
| 3  | 0.725 | 58   | 0.662  | 69   | 0.765 | 52   | 0.678 | 70   | 0.717 | 62   | 0.747 | 58   |
| 4  | 0.710 | 55   | 0.568  | 81   | 0.738 | 49   | 0.651 | 67   | 0.692 | 60   | 0.732 | 54   |
| 5  | 0.678 | 51   | 0.400  | 101  | 0.703 | 43   | 0.597 | 62   | 0.662 | 54   | 0.707 | 48   |
| 6  | 0.656 | 50   | 0.412  | 93   | 0.652 | 42   | 0.605 | 55   | 0.632 | 52   | 0.725 | 41   |
| 7  | 0.592 | 58   | 0.303  | 108  | 0.571 | 48   | 0.567 | 59   | 0.568 | 59   | 0.699 | 43   |
| 8  | 0.557 | 68   | 0.335  | 113  | 0.539 | 59   | 0.594 | 62   | 0.532 | 70   | 0.700 | 46   |
| 9  | 0.499 | 75   | 0.201  | 134  | 0.468 | 64   | 0.555 | 64   | 0.491 | 72   | 0.658 | 49   |
| 10 | 0.529 | 73   | 0.229  | 136  | 0.484 | 65   | 0.633 | 55   | 0.546 | 66   | 0.712 | 43   |
| 11 | 0.527 | 71   | 0.194  | 141  | 0.464 | 64   | 0.647 | 51   | 0.564 | 61   | 0.720 | 40   |
| 12 | 0.591 | 61   | 0.337  | 119  | 0.551 | 55   | 0.719 | 40   | 0.641 | 49   | 0.786 | 30   |
| 13 | 0.629 | 50   | 0.355  | 107  | 0.590 | 43   | 0.719 | 37   | 0.676 | 40   | 0.780 | 27   |
| 14 | 0.639 | 50   | 0.504  | 88   | 0.612 | 43   | 0.701 | 41   | 0.686 | 40   | 0.780 | 28   |
| 15 | 0.635 | 48   | 0.561  | 76   | 0.590 | 43   | 0.654 | 46   | 0.672 | 40   | 0.735 | 32   |
| 16 | 0.548 | 62   | 0.594  | 72   | 0.510 | 55   | 0.596 | 55   | 0.605 | 50   | 0.662 | 43   |
| 17 | 0.548 | 67   | 0.422  | 100  | 0.501 | 62   | 0.612 | 59   | 0.594 | 57   | 0.647 | 50   |
| 18 | 0.504 | 75   | 0.252  | 132  | 0.507 | 65   | 0.621 | 59   | 0.573 | 61   | 0.634 | 53   |
| 19 | 0.532 | 73   | 0.034  | 167  | 0.589 | 58   | 0.617 | 62   | 0.572 | 64   | 0.621 | 58   |
| 20 | 0.497 | 80   | -0.030 | 187  | 0.594 | 59   | 0.603 | 64   | 0.549 | 69   | 0.601 | 61   |
| 21 | 0.482 | 78   | -0.083 | 189  | 0.601 | 56   | 0.558 | 68   | 0.535 | 66   | 0.572 | 62   |
| 22 | 0.436 | 83   | -0.018 | 181  | 0.552 | 63   | 0.482 | 78   | 0.507 | 69   | 0.519 | 68   |
| 23 | 0.443 | 79   | -0.045 | 183  | 0.513 | 68   | 0.414 | 85   | 0.498 | 69   | 0.473 | 72   |
| 24 | 0.445 | 86   | 0.007  | 188  | 0.478 | 80   | 0.379 | 99   | 0.518 | 73   | 0.452 | 83   |





Table M.2. Part a, cont'

|      |       |    |       |     |       |    |       |    |       |    |       |    |
|------|-------|----|-------|-----|-------|----|-------|----|-------|----|-------|----|
| 25   | 0.467 | 80 | 0.032 | 179 | 0.467 | 80 | 0.381 | 96 | 0.520 | 70 | 0.459 | 79 |
| 26   | 0.525 | 74 | 0.265 | 139 | 0.539 | 72 | 0.463 | 87 | 0.611 | 59 | 0.545 | 70 |
| 27   | 0.493 | 75 | 0.313 | 126 | 0.500 | 75 | 0.418 | 90 | 0.582 | 61 | 0.519 | 70 |
| 28   | 0.518 | 76 | 0.436 | 113 | 0.569 | 70 | 0.436 | 94 | 0.622 | 60 | 0.555 | 70 |
| MEAN | 0.561 | 68 | 0.322 | 121 | 0.576 | 59 | 0.582 | 66 | 0.593 | 61 | 0.649 | 54 |



Table M.2. Results Using Southern Data Set

NUMB = 240  
JWAVE = 8

Part b

|    | Unsmooth<br>NWAVE=2 |      | Smoother<br>No. 2<br>NWAVE=2 |      | Smoother<br>No. 3<br>NWAVE=2 |      | Unsmooth<br>NWAVE=3 |      | Smoother<br>No. 3<br>NWAVE=3 |      | Smoother<br>No. 1<br>NWAVE=4 |      |
|----|---------------------|------|------------------------------|------|------------------------------|------|---------------------|------|------------------------------|------|------------------------------|------|
|    | r                   | MSEE | r                            | MSEE | r                            | MSEE | r                   | MSEE | r                            | MSEE | r                            | MSEE |
| 0  | 0.743               | 45   | 0.544                        | 77   | 0.563                        | 68   | 0.713               | 53   | 0.643                        | 65   | 0.612                        | 74   |
| 1  | 0.750               | 50   | 0.533                        | 86   | 0.591                        | 73   | 0.683               | 64   | 0.662                        | 60   | 0.607                        | 84   |
| 2  | 0.815               | 48   | 0.601                        | 89   | 0.672                        | 76   | 0.733               | 67   | 0.725                        | 66   | 0.658                        | 86   |
| 3  | 0.827               | 39   | 0.602                        | 80   | 0.672                        | 67   | 0.711               | 64   | 0.681                        | 64   | 0.621                        | 89   |
| 4  | 0.820               | 36   | 0.577                        | 77   | 0.630                        | 67   | 0.696               | 61   | 0.617                        | 66   | 0.577                        | 94   |
| 5  | 0.798               | 31   | 0.540                        | 71   | 0.631                        | 54   | 0.673               | 56   | 0.572                        | 59   | 0.482                        | 101  |
| 6  | 0.737               | 34   | 0.511                        | 70   | 0.647                        | 47   | 0.624               | 58   | 0.560                        | 54   | 0.450                        | 98   |
| 7  | 0.619               | 46   | 0.459                        | 73   | 0.641                        | 47   | 0.518               | 69   | 0.544                        | 55   | 0.408                        | 99   |
| 8  | 0.557               | 59   | 0.401                        | 88   | 0.660                        | 50   | 0.504               | 75   | 0.576                        | 58   | 0.448                        | 96   |
| 9  | 0.486               | 65   | 0.380                        | 86   | 0.626                        | 53   | 0.445               | 79   | 0.573                        | 56   | 0.458                        | 88   |
| 10 | 0.486               | 67   | 0.455                        | 78   | 0.692                        | 46   | 0.455               | 78   | 0.654                        | 48   | 0.482                        | 67   |
| 11 | 0.477               | 65   | 0.474                        | 72   | 0.688                        | 45   | 0.433               | 77   | 0.644                        | 48   | 0.616                        | 58   |
| 12 | 0.510               | 62   | 0.549                        | 61   | 0.764                        | 35   | 0.458               | 72   | 0.702                        | 41   | 0.724                        | 41   |
| 13 | 0.534               | 51   | 0.590                        | 48   | 0.759                        | 33   | 0.442               | 66   | 0.687                        | 38   | 0.688                        | 42   |
| 14 | 0.534               | 55   | 0.614                        | 47   | 0.773                        | 32   | 0.450               | 68   | 0.672                        | 42   | 0.666                        | 45   |
| 15 | 0.508               | 56   | 0.630                        | 42   | 0.707                        | 41   | 0.422               | 68   | 0.606                        | 49   | 0.579                        | 53   |
| 16 | 0.447               | 68   | 0.539                        | 55   | 0.646                        | 52   | 0.420               | 73   | 0.555                        | 59   | 0.561                        | 58   |
| 17 | 0.485               | 70   | 0.507                        | 64   | 0.581                        | 65   | 0.433               | 78   | 0.512                        | 71   | 0.535                        | 68   |
| 18 | 0.523               | 69   | 0.485                        | 69   | 0.563                        | 70   | 0.482               | 75   | 0.531                        | 70   | 0.576                        | 64   |
| 19 | 0.609               | 60   | 0.521                        | 67   | 0.557                        | 73   | 0.559               | 67   | 0.567                        | 67   | 0.581                        | 67   |
| 20 | 0.600               | 65   | 0.500                        | 72   | 0.570                        | 72   | 0.592               | 65   | 0.598                        | 63   | 0.590                        | 68   |
| 21 | 0.621               | 62   | 0.517                        | 67   | 0.544                        | 72   | 0.626               | 57   | 0.579                        | 63   | 0.576                        | 71   |
| 22 | 0.580               | 69   | 0.507                        | 67   | 0.597                        | 78   | 0.646               | 56   | 0.518                        | 71   | 0.524                        | 81   |
| 23 | 0.554               | 74   | 0.490                        | 69   | 0.424                        | 87   | 0.618               | 62   | 0.432                        | 81   | 0.447                        | 97   |



Table M.2.      Part b    cont'

|      |       |    |       |    |       |     |       |    |       |     |       |     |
|------|-------|----|-------|----|-------|-----|-------|----|-------|-----|-------|-----|
| 24   | 0.520 | 85 | 0.490 | 77 | 0.397 | 99  | 0.571 | 77 | 0.396 | 94  | 0.421 | 111 |
| 25   | 0.522 | 84 | 0.491 | 75 | 0.364 | 100 | 0.527 | 85 | 0.350 | 98  | 0.386 | 118 |
| 26   | 0.582 | 77 | 0.572 | 66 | 0.443 | 90  | 0.573 | 81 | 0.401 | 93  | 0.426 | 114 |
| 27   | 0.572 | 77 | 0.569 | 64 | 0.398 | 93  | 0.525 | 89 | 0.327 | 99  | 0.370 | 119 |
| 28   | 0.609 | 75 | 0.619 | 61 | 0.434 | 93  | 0.553 | 88 | 0.358 | 101 | 0.394 | 118 |
| MEAN | 0.595 | 61 | 0.526 | 69 | 0.592 | 65  | 0.549 | 70 | 0.557 | 65  | 0.534 | 82  |



Table M.2. Results Using Southern Data Set NUMB = 240 Part c

|    | Smoother<br>No. 2<br>NWAve=4<br>JWAve=8 |      |  | Smoother<br>No. 3<br>NWAve=4<br>JWAve=8 |      |  | Smoother<br>No. 3<br>NWAve=5<br>JWAve=8 |      |  | Smoother<br>No. 3<br>NWAve=2<br>JWAve=5 |      |  | Smoother<br>No. 3<br>NWAve=2<br>JWAve=11 |      |  | Smoother<br>No. 3 |
|----|-----------------------------------------|------|--|-----------------------------------------|------|--|-----------------------------------------|------|--|-----------------------------------------|------|--|------------------------------------------|------|--|-------------------|
|    | r                                       | MSEE |  | r                                       | MSEE |  | r                                       | MSEE |  | r                                       | MSEE |  | r                                        | MSEE |  |                   |
| 0  | 0.591                                   | 72   |  | 0.695                                   | 51   |  | 0.699                                   | 56   |  | 0.542                                   | 71   |  | 0.571                                    | 67   |  |                   |
| 1  | 0.564                                   | 82   |  | 0.709                                   | 54   |  | 0.710                                   | 58   |  | 0.566                                   | 76   |  | 0.581                                    | 75   |  |                   |
| 2  | 0.626                                   | 83   |  | 0.747                                   | 59   |  | 0.749                                   | 51   |  | 0.647                                   | 80   |  | 0.665                                    | 77   |  |                   |
| 3  | 0.624                                   | 74   |  | 0.701                                   | 59   |  | 0.698                                   | 63   |  | 0.642                                   | 71   |  | 0.671                                    | 67   |  |                   |
| 4  | 0.605                                   | 71   |  | 0.625                                   | 66   |  | 0.630                                   | 71   |  | 0.615                                   | 68   |  | 0.632                                    | 66   |  |                   |
| 5  | 0.579                                   | 66   |  | 0.575                                   | 62   |  | 0.575                                   | 70   |  | 0.599                                   | 58   |  | 0.628                                    | 55   |  |                   |
| 6  | 0.540                                   | 68   |  | 0.555                                   | 60   |  | 0.555                                   | 69   |  | 0.617                                   | 50   |  | 0.651                                    | 47   |  |                   |
| 7  | 0.468                                   | 76   |  | 0.529                                   | 63   |  | 0.522                                   | 71   |  | 0.597                                   | 51   |  | 0.640                                    | 47   |  |                   |
| 8  | 0.433                                   | 88   |  | 0.551                                   | 66   |  | 0.548                                   | 72   |  | 0.613                                   | 56   |  | 0.657                                    | 50   |  |                   |
| 9  | 0.391                                   | 90   |  | 0.550                                   | 65   |  | 0.534                                   | 70   |  | 0.579                                   | 58   |  | 0.627                                    | 52   |  |                   |
| 10 | 0.476                                   | 80   |  | 0.641                                   | 54   |  | 0.638                                   | 55   |  | 0.643                                   | 52   |  | 0.694                                    | 46   |  |                   |
| 11 | 0.478                                   | 77   |  | 0.655                                   | 50   |  | 0.646                                   | 51   |  | 0.647                                   | 51   |  | 0.686                                    | 46   |  |                   |
| 12 | 0.577                                   | 62   |  | 0.730                                   | 39   |  | 0.722                                   | 39   |  | 0.738                                   | 38   |  | 0.765                                    | 35   |  |                   |
| 13 | 0.572                                   | 57   |  | 0.696                                   | 40   |  | 0.671                                   | 41   |  | 0.744                                   | 34   |  | 0.762                                    | 33   |  |                   |
| 14 | 0.608                                   | 54   |  | 0.685                                   | 42   |  | 0.646                                   | 45   |  | 0.774                                   | 32   |  | 0.773                                    | 32   |  |                   |
| 15 | 0.605                                   | 53   |  | 0.619                                   | 49   |  | 0.577                                   | 53   |  | 0.712                                   | 40   |  | 0.702                                    | 42   |  |                   |
| 16 | 0.563                                   | 61   |  | 0.556                                   | 61   |  | 0.523                                   | 62   |  | 0.651                                   | 50   |  | 0.636                                    | 53   |  |                   |
| 17 | 0.503                                   | 74   |  | 0.494                                   | 76   |  | 0.478                                   | 75   |  | 0.580                                   | 65   |  | 0.585                                    | 64   |  |                   |
| 18 | 0.503                                   | 76   |  | 0.492                                   | 78   |  | 0.497                                   | 74   |  | 0.569                                   | 69   |  | 0.567                                    | 70   |  |                   |
| 19 | 0.504                                   | 79   |  | 0.519                                   | 77   |  | 0.546                                   | 71   |  | 0.572                                   | 70   |  | 0.556                                    | 73   |  |                   |
| 20 | 0.482                                   | 82   |  | 0.547                                   | 75   |  | 0.589                                   | 66   |  | 0.586                                   | 68   |  | 0.565                                    | 73   |  |                   |
| 21 | 0.490                                   | 77   |  | 0.546                                   | 71   |  | 0.600                                   | 61   |  | 0.570                                   | 67   |  | 0.537                                    | 73   |  |                   |
| 22 | 0.451                                   | 80   |  | 0.497                                   | 77   |  | 0.558                                   | 68   |  | 0.547                                   | 69   |  | 0.501                                    | 77   |  |                   |
| 23 | 0.446                                   | 79   |  | 0.469                                   | 81   |  | 0.530                                   | 74   |  | 0.482                                   | 78   |  | 0.426                                    | 87   |  |                   |





Table M.2.      Part c      cont'

|      |       |    |       |     |       |     |       |    |       |     |
|------|-------|----|-------|-----|-------|-----|-------|----|-------|-----|
| 24   | 0.439 | 87 | 0.460 | 90  | 0.504 | 87  | 0.457 | 87 | 0.389 | 100 |
| 25   | 0.409 | 90 | 0.438 | 91  | 0.470 | 93  | 0.441 | 87 | 0.369 | 99  |
| 26   | 0.444 | 88 | 0.474 | 87  | 0.488 | 94  | 0.526 | 75 | 0.449 | 89  |
| 27   | 0.409 | 90 | 0.403 | 95  | 0.414 | 103 | 0.484 | 79 | 0.405 | 91  |
| 28   | 0.445 | 91 | 0.410 | 100 | 0.429 | 108 | 0.494 | 82 | 0.427 | 94  |
| MEAN | 0.508 | 76 | 0.567 | 67  | 0.573 | 69  | 0.596 | 63 | 0.591 | 65  |



## APPENDIX N

### Actual Forecast Results (Northern Data Set)

Table N.1.

Results Using Northern Data Set NUMB = 240.

The value "r" in this Appendix is the correlation coefficient (i.e.  $r = R$ ).

NOTE: Forecast numbers are listed to the left of these tables. Forecast number = 0 is for the last diagnostic report and is not considered in the Mean at the bottom of the table.



Table N.1. Results Using Northern Data Set      NUMB=240  
(Part a)                                                      JWAVE= 8

|      | Persistence |      | Climatology |      | Unsmooth<br>NWAVE=2 |      | Unsmooth<br>NWAVE=3 |      |
|------|-------------|------|-------------|------|---------------------|------|---------------------|------|
|      | r           | MSEE | r           | MSEE | r                   | MSEE | r                   | MSEE |
| 0    | 1.000       | 0    | 0.835       | 28   | 0.464               | 54   | 0.439               | 48   |
| 1    | 0.874       | 14   | 0.723       | 37   | 0.205               | 74   | 0.283               | 62   |
| 2 *  |             |      |             |      |                     |      |                     |      |
| 3    | 0.476       | 64   | 0.485       | 64   | 0.191               | 83   | 0.295               | 71   |
| 4    | 0.352       | 84   | 0.395       | 82   | 0.296               | 84   | 0.303               | 80   |
| 5    | 0.330       | 89   | 0.392       | 86   | 0.422               | 76   | 0.336               | 82   |
| 6    | 0.339       | 93   | 0.415       | 92   | 0.583               | 69   | 0.415               | 84   |
| 7    | 0.349       | 89   | 0.439       | 89   | 0.644               | 64   | 0.451               | 82   |
| 8    | 0.238       | 113  | 0.401       | 108  | 0.654               | 77   | 0.498               | 95   |
| 9    | 0.203       | 114  | 0.421       | 109  | 0.600               | 87   | 0.509               | 103  |
| 10   | 0.149       | 126  | 0.412       | 120  | 0.623               | 98   | 0.531               | 119  |
| 11   | 0.160       | 120  | 0.397       | 126  | 0.529               | 117  | 0.416               | 152  |
| 12   | 0.232       | 112  | 0.409       | 125  | 0.542               | 119  | 0.417               | 164  |
| 13   | 0.168       | 146  | 0.318       | 164  | 0.469               | 159  | 0.359               | 210  |
| 14   | 0.116       | 197  | 0.320       | 203  | 0.455               | 198  | 0.384               | 252  |
| 15   | 0.147       | 180  | 0.385       | 180  | 0.458               | 189  | 0.386               | 246  |
| 16   | 0.137       | 178  | 0.432       | 165  | 0.407               | 172  | 0.460               | 227  |
| 17   | 0.160       | 173  | 0.463       | 156  | 0.493               | 175  | 0.435               | 231  |
| 18   | 0.213       | 156  | 0.521       | 134  | 0.545               | 153  | 0.491               | 204  |
| 19   | 0.227       | 126  | 0.500       | 111  | 0.460               | 154  | 0.410               | 203  |
| 20   | 0.190       | 121  | 0.433       | 103  | 0.395               | 154  | 0.350               | 200  |
| 21   | 0.194       | 117  | 0.377       | 110  | 0.291               | 183  | 0.237               | 232  |
| 22   | 0.279       | 125  | 0.451       | 121  | 0.397               | 183  | 0.357               | 225  |
| 23   | 0.366       | 113  | 0.542       | 110  | 0.490               | 171  | 0.442               | 208  |
| 24   | 0.410       | 106  | 0.582       | 98   | 0.551               | 147  | 0.498               | 183  |
| 25   | 0.367       | 118  | 0.537       | 121  | 0.559               | 169  | 0.488               | 207  |
| 26   | 0.394       | 113  | 0.510       | 126  | 0.556               | 176  | 0.487               | 210  |
| 27   | 0.499       | 89   | 0.520       | 116  | 0.565               | 171  | 0.486               | 208  |
| 28   | 0.507       | 99   | 0.487       | 140  | 0.526               | 102  | 0.460               | 234  |
| MEAN | 0.323       | 127  | 0.491       | 128  | 0.464               | 132  | 0.447               | 183  |

\* The actual data for forecast No. 2 were missing and would appear in the printout as:

|       |       |
|-------|-------|
| r     | MSEE  |
| 99.99 | -10.0 |



Table N.1. Results Using Northern Data Set NUMB=240  
 (Part b) JWAVE= 8  
 Smoothing Option=No. 3

|      | NWAVE = 1 |      | NWAVE = 3 |      | NWAVE = 5 |      | NWAVE = 7 |      |
|------|-----------|------|-----------|------|-----------|------|-----------|------|
|      | r         | MSEE | r         | MSEE | r         | MSEE | r         | MSEE |
| 0    | 0.788     | 21   | 0.651     | 42   | 0.650     | 40   | 0.557     | 49   |
| 1    | 0.674     | 32   | 0.576     | 53   | 0.526     | 54   | 0.315     | 83   |
| 2*   |           |      |           |      |           |      |           |      |
| 3    | 0.602     | 43   | 0.582     | 56   | 0.491     | 63   | 0.183     | 118  |
| 4    | 0.648     | 43   | 0.680     | 46   | 0.628     | 51   | 0.348     | 103  |
| 5    | 0.712     | 38   | 0.756     | 37   | 0.668     | 47   | 0.408     | 96   |
| 6    | 0.748     | 38   | 0.806     | 33   | 0.734     | 43   | 0.519     | 81   |
| 7    | 0.759     | 36   | 0.811     | 32   | 0.738     | 41   | 0.535     | 75   |
| 8    | 0.719     | 49   | 0.743     | 49   | 0.733     | 51   | 0.562     | 75   |
| 9    | 0.724     | 49   | 0.683     | 57   | 0.633     | 64   | 0.507     | 80   |
| 10   | 0.633     | 68   | 0.549     | 78   | 0.587     | 75   | 0.527     | 81   |
| 11   | 0.614     | 73   | 0.587     | 73   | 0.619     | 73   | 0.590     | 75   |
| 12   | 0.627     | 72   | 0.632     | 66   | 0.726     | 63   | 0.752     | 64   |
| 13   | 0.546     | 104  | 0.575     | 91   | 0.692     | 89   | 0.650     | 98   |
| 14   | 0.472     | 149  | 0.423     | 145  | 0.569     | 139  | 0.356     | 165  |
| 15   | 0.478     | 138  | 0.406     | 135  | 0.493     | 136  | 0.159     | 177  |
| 16   | 0.462     | 136  | 0.313     | 141  | 0.427     | 139  | 0.056     | 191  |
| 17   | 0.458     | 135  | 0.333     | 137  | 0.407     | 140  | 0.049     | 199  |
| 18   | 0.435     | 130  | 0.257     | 137  | 0.351     | 138  | 0.021     | 200  |
| 19   | 0.321     | 120  | 0.243     | 110  | 0.315     | 117  | 0.077     | 168  |
| 20   | 0.113     | 133  | 0.105     | 112  | 0.250     | 113  | 0.128     | 150  |
| 21   | 0.019     | 147  | 0.099     | 110  | 0.175     | 123  | 0.132     | 151  |
| 22   | 0.062     | 161  | 0.094     | 138  | 0.109     | 158  | 0.032     | 191  |
| 23   | 0.142     | 152  | 0.156     | 136  | 0.116     | 163  | 0.026     | 195  |
| 24   | 0.174     | 145  | 0.205     | 134  | 0.147     | 158  | 0.098     | 177  |
| 25   | 0.145     | 159  | 0.215     | 152  | 0.188     | 170  | 0.204     | 176  |
| 26   | 0.151     | 161  | 0.253     | 156  | 0.198     | 174  | 0.296     | 166  |
| 27   | 0.278     | 134  | 0.391     | 138  | 0.323     | 150  | 0.451     | 138  |
| 28   | 0.402     | 140  | 0.521     | 152  | 0.369     | 170  | 0.557     | 150  |
| MEAN | 0.483     | 111  | 0.480     | 108  | 0.488     | 116  | 0.342     | 145  |

\* See Part a of this table.

















**B30212**